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WATER QUALITY ASSESSMENT OF LAKE ATHAPAPUSKOW, MANITOBA, CANADA

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Hughes C. E. Water quality assessment of Lake Athapapuskow, Manitoba, Canada. June 2002.

BACKGROUND

Lake Athapapuskow (54° 33' N, 101° 40' W) stretches from Cranberry Portage in the east to just west of the Saskatchewan border. The lake has a surface area of 25,434 ha, a maximum depth of 64 m and a mean depth of 16.2 m[1]. Lake Athapapuskow consists of a large, deeper southern basin, and a smaller, shallower northern basin. The northern basin is often referred to as Little Athapapuskow Lake. Bakers Narrows splits the northern basin into two smaller basins. This study concentrated on the area near the town of Cranberry Portage in the main basin of the lake, and the cottage and permanent residence developments on Little Athapapuskow Lake (Figure 1).

The southern portion of the main basin of Lake Athapapuskow has limestone bedrock while the northern portion of the lake including all of Little Athapapuskow Lake lies in a granite and greenstone belt. The surficial deposits are mostly till with some bog at the east end of the main basin of the lake. Soils are mainly Gray Luvisol on the south shore of the lake and mostly Dystric Brunisol on the north shore of the main basin and in the area surrounding Little Athapapuskow Lake. Vegetation is predominantly mixed broadleaf and coniferous species with some northern coniferous forest at the west end of the lake.

METHODS

Three water quality sampling sites were located near Cranberry Portage in the main basin of Lake Athapapuskow, while seven water quality sampling sites were located in the northern basin with two to the north and five to the south of Bakers Narrows (Figure 1). On June 25 and 26, 2001 initial samples were collected within the euphotic zone at each site. Water from these samples was analyzed for over 100 variables including general chemistry, nutrients, fecal coliform bacteria, dissolved oxygen, major ions, heavy metals, pesticides, and others.

Subsequently, volunteers collected six more sets of water samples near the surface between the beginning of July and mid-September 2001. Water from the volunteer sampling was analyzed for phosphorus, various nitrogen compounds, fecal coliform bacteria, and chlorophyll *a*, as well as pH, conductivity, and turbidity. Trace metals and major ion analyses were also included in the first set of volunteer samples. Volunteer sampling procedures during the summer included measuring the Secchi disk depth. The Secchi disk is a 20 cm diameter black and white disk that is lowered into the water to a point where it disappears from sight and this depth is recorded. Samples were collected, where possible, throughout the water column to a depth of twice the Secchi disk depth. A depth of twice the Secchi disk depth is the approximate depth of the euphotic zone, or zone of light penetration where algal photosynthesis can occur. Volunteers also recorded water temperatures.

Data collected over the summer of 2001 were compared using Student's "t" tests. A Student's "t" test ($\alpha = 0.05$) was used to test for differences in concentrations between the north and south basins on Lake Athapapuskow. Except for pH, other data were converted to logarithms to reduce the variance before Student's "t" tests were performed. These comparisons were also made between the 2001 data for each basin and data from 1976 through 1978 for site WQ0089 near Cranberry Portage and data from 1976 through 1984 for site WQ0088 near Bakers Narrows.

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[1] Lake Athapapuskow morphometry, courtesy of D. Leroux.

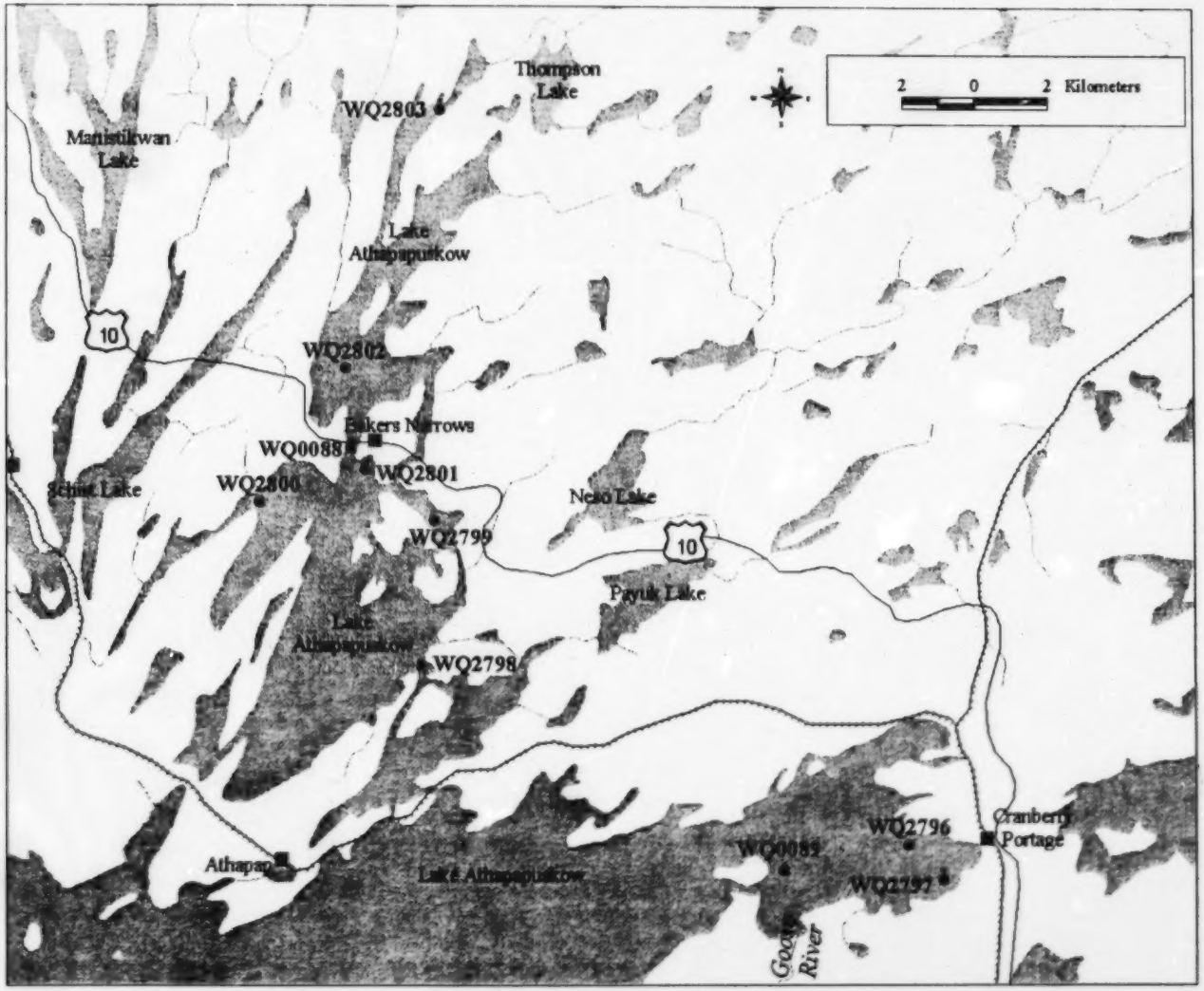

Figure 1. Water quality monitoring sites on Lake Athapapuskow.

Water Quality Index

Water quality is typically assessed by measuring a large number of variables, including bacteria, plant nutrients, major ions, trace metals, industrial organics, agricultural pesticides and many others. The Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) was used to describe the overall quality of water in Lake Athapapuskow (CCME 2000). Some 25 variables were compared with water quality guidelines and objectives (Williamson 1988, 2001) to calculate the CCME WQI.

The CCME WQI mathematically incorporates information on water quality from three factors. The basic premise of the index is that water quality is excellent when all water quality guidelines or objectives set to protect water uses are met virtually all the time. When guidelines or objectives are not met, water quality becomes progressively poorer. This depends upon the number of water quality variables for the objectives or guidelines that are not met (Factor 1), the percentage of time they are not met (Factor 2), and an equation which uses the normalized sum of departures from objectives (Factor 3).

For example, progressively smaller index values result when guidelines or objectives are exceeded for more water quality variables (*i.e.*, excursions for one variable will have less impact on water uses than simultaneous excursions for many water quality variables), when excursions occur during longer periods of time (*i.e.*, an exceedence for a brief period will have less impact on a water use than an exceedence for an extended period), and when the overall magnitude of excursions increase (*i.e.*, an exceedence slightly above a water quality guideline or objective will have less impact on a water use than an exceedence that is several times higher). Thus, the index logically incorporates information on water quality based on comparisons to guidelines or objectives to protect important water uses. The CCME WQI ranges from 0 to 100 and was used to rank water quality in categories ranging from poor to excellent. An excellent CCME WQI rating (95-100) indicates that all water uses are protected, with a virtual absence of impairment or only a minimal degree of impairment. A good CCME WQI rating (80-94) indicates that all water quality uses are protected with only a minor degree of impairment. A fair CCME WQI rating (60-79) indicates that most water uses are protected but a few may be impaired. A marginal CCME WQI rating (45-59) indicates that several water uses may be impaired while a poor CCME WQI rating (0-44) indicates that most water uses are impaired.

RESULTS AND DISCUSSION

The emphasis in the Lake Athapapuskow study was on changes in phosphorus, nitrate-nitrite nitrogen, ammonia, total Kjeldahl nitrogen, chlorophyll *a*, turbidity, and bacteria over the summer of 2001. Temperature, pH, and conductivity were also measured in water samples from Lake Athapapuskow between June 25 to September 17, 2001. Averages and standard deviations for these variables for each month and for each site for Lake Athapapuskow (Figure 1) during 2001 are shown in Table 1. Appendix 1 includes all individual sample results of analyses for each sample for the variables noted in Table 1. Analytical results for over 100 variables measured in water samples collected on June 25 and 26, 2001 are shown in Table 2. Average historical and recent water quality data for site WQ0089 in the main basin and WQ0088 in the north basin are shown in Table 3. Appendix 2 includes data for individual samples collected in the 1970s and 1980s that were used to derive the averages and standard deviations in Table 3. The differences between basins and time periods for the most commonly sampled variables on Lake Athapapuskow are shown in Table 4. Table 5 is a summary listing of objectives, where available, for most of the water quality variables sampled during 2001.

Nutrients

Nutrients required for the growth of algae and other plants include phosphorus and nitrogen compounds. Analyses were conducted for phosphorus, ammonia-ammonium nitrogen (also known as

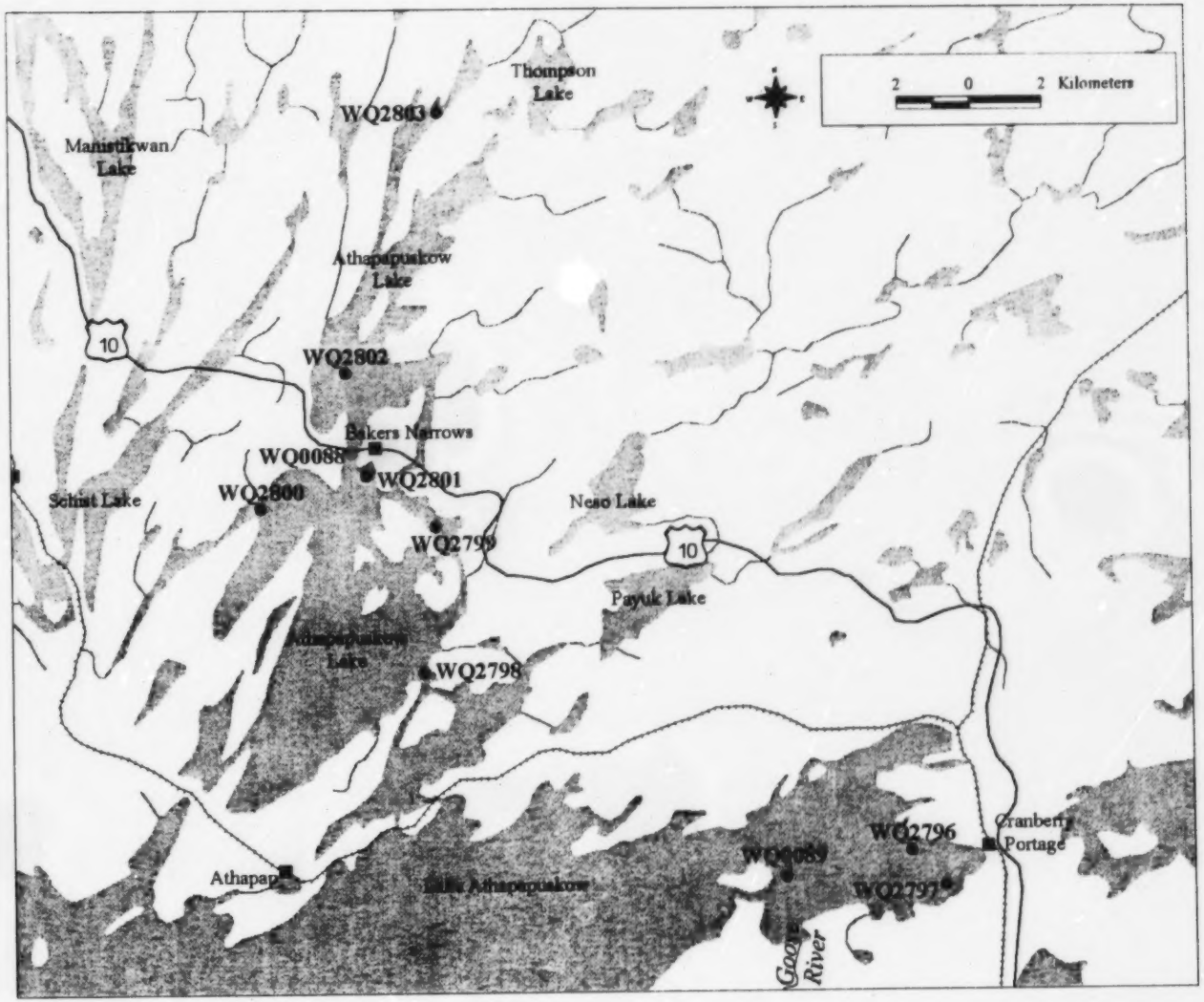

Figure 1. Water quality monitoring sites on Lake Athapapuskow.

Table 1. Average nutrients, chlorophyll *a*, bacteria, temperature, pH, conductivity, and turbidity in Lake Ahapapuskow water per site and per month during 2001.

Site or Month	Statistic	Temperature	Fecal Coliform Bacteria[1] MF	E-Coli Bacteria[1] MF	pH Laboratory	Specific Conductivity, Lab.	Turbidity Laboratory	Secchi Disc Depth	Nitrate & Nitrite Nitrogen N	Total Ammonia Nitrogen N	Total Phosphorus	Particulate Phosphorus	Dissolved Phosphorus	Chlorophyll *a*
Site[2]	Units	°C	Bacteria/100mL	Bacteria/100mL	pH units	uS/cm	NTU	m	mg/L	mg/L	mg/L as P	mg/L as P	mg/L as P	ug/L
WQ2796	Average	17.6	10	10	7.79	340	0.71	5.0	0.04	0.05	0.008	0.004	0.005	0.7
WQ2796	Std. Deviation	3.0	0	0	0.38	17	0.34	0.5	0.03	0.04	0.002	0.002	0.002	0.4
WQ2796	Count	7	7	7	7	7	7	7	7	7	7	7	7	7
WQ2797	Average	17.7	< 10	< 10	7.79	339	0.57	5.3	0.04	0.05	0.008	0.003	0.005	0.7
WQ2797	Std. Deviation	2.6	0	0	0.30	16	0.12	0.9	0.02	0.02	0.002	0.001	0.002	0.5
WQ2797	Count	7	7	7	7	7	7	7	7	7	7	7	7	7
WQ0069	Average	17.5	< 10	11	7.83	339	0.54	5.9	0.04	0.04	0.008	0.004	0.004	0.6
WQ0069	Std. Deviation	2.4	0	4	0.27	18	0.14	0.9	0.04	0.02	0.003	0.002	0.001	0.4
WQ0069	Count	7	7	7	7	7	7	7	7	7	7	7	7	7
WQ2798	Average	17.7	< 10	< 10	7.65	551	1.35	3.5	0.02	0.05	0.016	0.008	0.008	1.6
WQ2798	Std. Deviation	2.1	0	0	0.46	7	0.98	0.4	0.00	0.02	0.002	0.003	0.003	0.7
WQ2798	Count	7	5	5	7	6	7	7	7	7	7	7	7	6
WQ2799	Average	18.9	< 10	< 10	7.65	537	0.75	3.1	0.06	0.04	0.021	0.010	0.011	1.9
WQ2799	Std. Deviation	2.5	0	0	0.35	22	0.64	0.5	0.07	0.02	0.006	0.005	0.002	0.8
WQ2799	Count	7	6	6	7	7	7	7	7	7	7	7	7	7
WQ2800	Average	18.1	11	12	7.80	566	0.61	3.1	0.05	0.04	0.017	0.009	0.008	1.7
WQ2800	Std. Deviation	2.0	4	8	0.34	18	0.10	0.4	0.05	0.01	0.004	0.003	0.003	0.8
WQ2800	Count	7	6	6	7	7	7	7	7	7	7	7	7	7
WQ2801	Average	18.4	< 10	< 10	7.83	556	0.66	3.2	0.04	0.04	0.019	0.012	0.007	1.7
WQ2801	Std. Deviation	2.6	0	0	0.35	28	0.14	0.7	0.04	0.02	0.007	0.007	0.002	0.6
WQ2801	Count	7	6	6	7	7	7	7	7	7	7	7	7	7
WQ0068	Average	18.1	< 10	< 10	7.80	493	0.56	3.2	0.04	0.04	0.016	0.008	0.008	1.6
WQ0068	Std. Deviation	2.1	0	0	0.34	74	0.08	0.4	0.03	0.02	0.005	0.003	0.003	0.7
WQ0068	Count	7	6	6	7	7	7	7	7	7	7	7	7	7
WQ2802	Average	17.6	< 10	< 10	7.76	378	0.42	4.1	0.05	0.04	0.016	0.008	0.007	1.7
WQ2802	Std. Deviation	1.7	0	0	0.33	70	0.06	0.5	0.03	0.02	0.004	0.003	0.002	0.8
WQ2802	Count	7	5	5	7	7	7	7	7	7	7	7	7	7
WQ2803	Average	17.1	< 10	< 10	7.73	341	0.48	3.5	0.03	0.05	0.015	0.008	0.007	1.9
WQ2803	Std. Deviation	3.4	0	0	0.31	15	0.09	0.6	0.02	0.03	0.003	0.004	0.002	1.1
WQ2803	Count	7	6	6	7	7	7	7	7	7	7	7	7	7
Month														
June 2001	Average	15.4	< 10	< 10	7.24	447	0.74	3.7	0.02	0.05	0.015	0.006	0.010	1.2
June 2001	Std. Deviation	1.4	0	0	0.36	99	0.53	0.5	0.00	0.01	0.009	0.006	0.004	0.4
June 2001	Count	10	10	10	10	10	10	10	10	10	10	10	10	10
July 2001	Average	18.5	< 10	< 10	7.93	465	0.67	4.1	0.03	0.05	0.012	0.006	0.006	1.2
July 2001	Std. Deviation	1.3	2	2	0.14	109	0.31	1.2	0.02	0.02	0.003	0.002	0.003	0.9
July 2001	Count	20	19	19	20	19	20	20	20	20	20	20	20	19
August 2001	Average	20.4	< 10	< 11	7.95	438	0.74	4.0	0.03	0.03	0.013	0.007	0.007	1.7
August 2001	Std. Deviation	1.5	0	5	0.12	106	0.67	1.3	0.02	0.01	0.005	0.003	0.002	0.9
August 2001	Count	20	19	19	20	20	20	20	20	20	20	20	20	20
September 2001	Average	16.1	< 10	< 10	7.67	424	0.55	4.0	0.06	0.05	0.017	0.010	0.007	1.5
September 2001	Std. Deviation	1.4	0	0	0.28	107	0.12	1.2	0.06	0.03	0.007	0.006	0.002	0.8
September 2001	Count	20	13	13	20	20	20	20	20	20	20	20	20	20

1. Average bactera is a geometric mean.
2. For Site locations see Figure 1

Table 2. All physical, chemical and biological variables in water for Lake Athapapuskow in June 2001.

Site Description	Units	Athapapuskow L. East Arm W. of Cranberry Portage	Athapapuskow L. S.E. corner of E Arm, S. of Cranberry Portage	Athapapuskow L. E of Four Mile Island near Goose R.	Athapapuskow L. Mink Narrows	Athapapuskow L. southeast of Bakers Narrows	Athapapuskow L. mouth of Schist Cr. Bay	Athapapuskow L. Bay, south of Bakers Narrows	Athapapuskow L. west Bakers Narrows channel	Athapapuskow L. Centre of bay N of Bakers Narrows	Athapapuskow L. S of Narrow Point in Sourdough Bay
Database Site		MB05KGS044	MB05KGS045	MB05KGS058	MB05KGS046	MB05KGS047	MB05KGS048	MB05KGS049	MB05KGS055	MB05KGS050	MB05KGS051
Map Site		WQ2796	WQ2797	WQ0089	WQ2798	WQ2799	WQ2800	WQ2801	WQ0088	WQ2802	WQ2803
Date Sampled		2001-06-26	2001-06-26	2001-06-26	2001-06-25	2001-06-25	2001-06-25	2001-06-25	2001-06-25	2001-06-25	2001-06-25
Parameter											
Bacteria											
Fecal Coliform Bacteria MF	N/100mL	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
E Coli Bacteria MF	N/100mL	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Conventional Parameters											
Temperature	°C	13.0	14.0	15.0	15.0	18.0	15.0	15.0	16.0	16.0	17.0
Secchi Disk Depth	m	4.0	3.4	4.0	3.7	3.4	3.2	3.9	3.1	4.4	4.3
pH, Laboratory	pH units	8.24	7.22	7.28	7.09	7.04	7.13	7.11	7.11	7.07	7.06
Specific Conductivity, Lab.	uS/cm	353	360	352	562	539	545	562	486	368	343
Total Dissolved Solids	mg/L	201	218	199	404	376	356	330	329	262	178
Total Suspended Solids	mg/L	< 1	< 1	< 1	< 1	12	< 1	< 1	< 1	< 1	< 1
Turbidity, Laboratory	NTU	0.8	0.62	0.75	0.5	2.2	0.64	0.53	0.52	0.42	0.37
True Color (in Colour Units)	CU	< 5	< 5	< 5	< 5	5	< 5	< 5	< 5	5	5
Total Alkalinity $CaCO_3$	mg/L	77.2	74.4	72.2	67.1	71.8	66.6	63.6	66.6	173*	72.2
Bicarbonate Alkalinity HCO_3	mg/L	94.1	90.7	88.1	81.9	87.6	81.3	77.6	81.3	211*	88.1
Carbonate Alkalinity CO_3	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Hydroxide Alkalinity OH	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Dissolved Oxygen	mg/L	9.8	9.8	10.4	10.3	9.4	10.3	10.2	10.0	9.9	9.9
Total Organic Carbon C	mg/L	5.3	5.1	5.2	7.1	7.8	7.3	7.1	7.6	8.3	8.5
Total Inorganic Carbon C	mg/L	16	16	16	16	16	16	16	16	16	16
Total Carbon C	mg/L	23	23	23	23	24	23	23	23	24	24
Nitrate and Nitrite N	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Ammonia Nitrogen N	mg/L	0.03	0.05	0.03	0.05	0.05	0.05	0.06	0.05	0.06	0.05
Total Kjeldahl Nitrogen N	mg/L	0.7	< 0.5	0.5	< 0.5	0.5	0.5	0.6	0.6	0.8	0.6
Total Phosphorus	mg/L as P	0.006	0.005	0.005	0.015	0.033	0.023	0.020	0.019	0.013	0.012
Total Particulate Phosphorus	mg/L as P	< 0.002	< 0.002	< 0.002	< 0.002	0.020	0.010	0.009	0.006	0.005	0.002
Total Soluble Phosphorus	mg/L as P	0.005	0.005	0.005	0.014	0.013	0.013	0.011	0.013	0.008	0.010
Chlorophyll *a*	ug/L	0.8	0.7	0.7	1.2	1.8	1.3	1.2	1.3	1.5	1.2
Chloride Cl	mg/L	34.9	34.7	35.0	67.3	63.1	68.0	66.4	56.8	36.5	33.9
Sulphate SO_4	mg/L	52.5	52.4	52.7	117	108	119	116	96.1	59	55.7
Total Hardness $CaCO_3$	mg/L	143	137	142	224	199	221	221	194	141	130
Metals Analysis											
Total Aluminum Al	mg/L	0.044	0.022	0.036	0.038	0.015	0.034	0.022	0.031	0.011	0.018
Dissolved Aluminum Al	mg/L	0.002	0.002	0.018	0.020	0.010	0.015	0.012	0.010	0.008	0.007
Total Antimony Sb	mg/L	0.0005	0.0005	0.0005	0.0009	0.0008	0.0009	0.0008	0.0007	0.0006	0.0006
Total Arsenic As	mg/L	0.0010	0.0009	0.0009	0.0017	0.0017	0.0017	0.0015	0.0015	0.0016	0.0015
Total Barium Ba	mg/L	0.021	0.020	0.021	0.022	0.022	0.023	0.022	0.020	0.017	0.016
Total Beryllium Be	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Total Bismuth Bi	mg/L	0.0005	< 0.0002	< 0.0002	0.0013	< 0.0002	0.0013	0.0003	< 0.0002	0.0006	0.0003
Total Boron B	mg/L	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.01	0.01
Total Cadmium Cd	mg/L	0.00007	0.00011	0.00009	0.00016	0.00009	0.00016	0.00013	0.00014	0.00016	0.00014
Total Calcium Ca	mg/L	42.6	40.6	42.0	76.2	67.4	74.8	74.7	66.0	46.2	41.7
Total Cesium Cs	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Total Chromium Cr	mg/L	< 0.0002	< 0.0002	0.0002	0.0011	0.0003	0.0004	0.0004	0.0003	0.0003	0.0002
Total Cobalt Co	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Total Copper Cu	mg/L	0.0029	0.0024	0.0026	0.0032	0.0024	0.0034	0.0028	0.0027	0.0030	0.0033

Table 2. All physical, chemical and biological variables for Lake Athapapuskow in June 2001 (continued).

Site Description	Units	Athapapuskow L. East Arm W. of Cranberry Portage	Athapapuskow L. S.E. corner of E Arm, S. of Cranberry Portage	Athapapuskow L. E of Four Mile Island near Goose R.	Athapapuskow L. Mink Narrows	Athapapuskow L. southeast of Bakers Narrows	Athapapuskow L. mouth of Schist Cr. Bay	Athapapuskow L. Bay, south of Bakers Narrows	Athapapuskow L. west of Bakers Narrows channel	Athapapuskow L. Centre of bay N of Bakers Narrows	Athapapuskow L. S of Narrow Point in Sourdough Bay
Database Site		MB05KGS044	MB05KGS045	MB05KGS058	MB05KGS046	MB05KGS047	MB05KGS048	MB05KGS049	MB05KGS055	MB05KGS050	MB05KGS051
Map Site		WQ2796	WQ2797	WQ0069	WQ2798	WQ2799	WQ2800	WQ2801	WQ0088	WQ2802	WQ2803
Total Iron Fe	mg/L	0.10	0.10	0.10	0.17	0.13	0.16	0.14	0.12	0.09	0.09
Total Lead Pb	mg/L	< 0.0001	< 0.0001	0.0002	0.0002	< 0.0001	0.0003	< 0.0001	< 0.0001	0.0002	< 0.0001
Total Lithium Li	mg/L	0.0032	0.0032	0.0031	0.0045	0.0044	0.0042	0.0047	0.0035	0.0029	0.0026
Total Magnesium Mg	mg/L	8.87	8.62	8.93	8.07	7.44	8.16	8.31	6.99	6.18	6.12
Total Manganese Mn	mg/L	0.0020	0.0017	0.0017	0.0026	0.0090	0.0040	0.0041	0.0048	0.0069	0.0072
Total Molybdenum Mo	mg/L	0.0006	0.0003	0.0003	0.0008	0.0003	0.0009	0.0005	0.0003	0.0005	0.0003
Total Nickel Ni	mg/L	0.0004	0.0004	0.0004	0.0005	0.0010	0.0006	0.0005	0.0004	0.0003	0.0003
Total Phosphate PO_4	mg/L	0.059	0.060	0.050	0.081	0.094	0.084	0.078	0.060	0.083	0.058
Total Potassium K	mg/L	1.98	1.93	1.95	3.02	2.65	3.00	3.04	2.40	2.13	1.89
Total Rubidium Rb	mg/L	0.0014	0.0014	0.0014	0.0025	0.0023	0.0025	0.0024	0.0021	0.0017	0.0016
Total Selenium Se	mg/L	< 0.0004	< 0.0004	< 0.0004	0.0006	< 0.0004	0.0005	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Total Silicon SiO_2	mg/L	1.13	1.08	1.25	0.72	0.79	0.73	0.7	0.79	1.29	1.27
Total Silver Ag	mg/L	0.00007	0.00002	< 0.00002	0.00003	0.00004	0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002
Total Sodium Na	mg/L	11.7	11.1	11.8	20.3	17.8	20.2	20.4	15.7	11.1	10.5
Total Strontium Sr	mg/L	0.282	0.277	0.282	0.559	0.513	0.575	0.560	0.433	0.304	0.281
Total Tellurium Te	mg/L	0.0014	0.0003	< 0.0002	0.0022	< 0.0002	0.0022	0.0003	< 0.0002	0.001	0.0004
Total Thallium Tl	mg/L	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002
Total Thorium Th	mg/L	0.001	0.0002	0.0002	0.0014	0.0002	0.0013	0.0003	0.0001	0.0006	0.0002
Total Tin Sn	mg/L	0.0016	0.0014	0.0029	0.0028	0.0019	0.0027	0.0014	0.002	0.0021	0.0018
Total Titanium Ti	mg/L	0.0013	0.0012	0.0013	0.0019	0.0006	0.0018	0.0011	0.0013	0.0005	0.0006
Total Uranium U	mg/L	0.0001	0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Total Vanadium V	mg/L	0.0005	0.0005	0.0006	0.0004	0.0004	0.0005	0.0004	0.0004	0.0003	0.0003
Total Zinc Zn	mg/L	0.003	0.005	0.012	0.014	0.007	0.014	0.014	0.012	0.009	0.008
Total Zirconium Zr	mg/L	0.003	< 0.002	0.006	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chlorinated Phenols											
Pentachlorophenol	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.27	< 0.02	< 0.02	< 0.02	< 0.02
Chlorinated Acid Herbicides											
2,4-D	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
2,4-DB	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
2,4-DP	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
2,4,5-TP	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Bromoxynil	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dicamba	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dinoseb	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Fenoxaprop	ug/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MCPA	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
MCPP	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Picloram	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Quizalofop	ug/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Trichlopyr	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Organochlorine Pesticides											
Aldrin	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
alpha-BHC	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
beta-BHC	ug/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
delta-BHC	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
gamma-BHC (Lindane)	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
alpha-Chlordane	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Table 2. Physical, chemical and biological variables for Lake Athapapuskow in June 2001 (continued).

Site Description Database Site Map Site	Units	Athapapuskow L. East Arm W. of Cranberry Portage MB05KGS044 WQ2796	Athapapuskow L. S.E. corner of E Arm, S. of Cranberry Portage MB05KGS045 WQ2797	Athapapuskow L. E of Four Mile Island near Goose R. MB05KGS058 WQ0089	Athapapuskow L. Mink Narrows MB05KGS046 WQ2798	Athapapuskow L. southeast of Bakers Narrows MB05KGS047 WQ2799	Athapapuskow L. mouth of Schist Cr. Bay MB05KGS048 WQ2800	Athapapuskow L. Bay, south of Bakers Narrows MB05KGS049 WQ2801	Athapapuskow L. west of Bakers Narrows channel MB05KGS055 WQ0088	Athapapuskow L. Centre of bay N of Bakers Narrows MB05KGS050 WQ2802	Athapapuskow L. S of Narrow Point in Sourdough Bay MB05KGS051 WQ2803
gamma-Chlordane	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
p,p-DDD	ug/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
o,p-DDE	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
p,p-DDE	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
p,p-DDT	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dieldrin	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Endosulfan I	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Endrin	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Heptachlor	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Heptachlor Epoxide	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Methoxychlor	ug/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Mirex	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Carbamate Pesticides											
Carbofuran	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Propoxur	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Organonitrogen Pesticides											
Alachlor	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Atrazine	ug/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Bromacil	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Metribuzin	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Simazine	ug/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

a. Total and bicarbonate alkalinity data may be in error since results at site WQ2802 were twice those of results at other nearby sites.

Table 3. Historical and recent water quality data from two sites in Lake Athapapuskow, 1976 through 1984 and 2001.

Site	Date	Statistic	Temperature[1] Summer Only °C	Bacteria MF Equivalent Total Coliform Bacteria/100mL	Bacteria MF Equivalent Fecal Coliform Bacteria/100mL	pH Laboratory pH units	pH Field pH units	Specific Conductivity Laboratory uS/cm	Specific Conductivity Field	Total Dissolved Solids mg/L	Total Suspended Solids mg/L	Turbidity Laboratory NTU	True Colour Colour Units	Total Alkalinity CaCO3 mg/L	Bicarbonate Alkalinity HCO3 mg/L	Carbonate Alkalinity CO3 mg/L
East of Four Mile Island near Goose R.																
WQ0089	1976	Average		< 10	< 10	8.03		329		206	< 6	1.84	5	69	83.8	0
WQ0089	1976	Std. Deviation		0	0	0		20		13	1	3.31	1	9	11.2	0
WQ0089	1976	Count		7	7	8		8		8	8	9	8	8	8	8
WQ0089	1977	Average	15.0	< 10	< 10	8.03		325		221	< 5	0.83	< 5	63	77.3	0
WQ0089	1977	Std. Deviation	3.0	0	0	0.11		10		41	0	0.34	0	4	4.3	0
WQ0089	1977	Count	3	6	6	6		6		6	6	6	6	6	6	6
WQ0089	1978	Average	14.5	< 10	< 10	8.03		334	315		6					
WQ0089	1978	Std. Deviation	4.7	0	0	0.09		18	13		2					
WQ0089	1978	Count	4	7	7	7		7	6		3					
WQ0089	2001	Average	17.5		< 10	7.83		339		199	< 1	0.54	< 5	72	88.1	< 0.5
WQ0089	2001	Std. Deviation	2.4		0	0.27		18				0.14				
WQ0089	2001	Count	7		6	7		7		1	1	7	1	1	1	1
Near west Bakers Narrows channel																
WQ0088	1976	Average		< 10	< 10	7.81		440		291	5	2.04	< 7	61	74.4	0
WQ0088	1976	Std. Deviation		0	0	0.32		85		56	1	3.23	2	13	15.7	0
WQ0088	1976	Count		8	7	8		8		8	8	8	8	8	8	8
WQ0088	1977	Average	15.5	< 10	< 10	7.83		477		319	< 6	1.09	< 5	52	63.4	0
WQ0088	1977	Std. Deviation	3.8	0	0	0.20		18		13	1	0.46	0	7	8.2	0
WQ0088	1977	Count	3	6	6	6		6		6	6	6	6	6	6	6
WQ0088	1978	Average	16.1	< 10	< 10	7.79	7.67	455	453		< 8					
WQ0088	1978	Std. Deviation	4.6	0	0	0.25	0.39	53	87		4					
WQ0088	1978	Count	4	7	7	7	5	7	6		3					
WQ0088	1979	Average	16.5	< 11	< 10	7.86		436[a]	480		5					
WQ0088	1979	Std. Deviation	5.3	2	0	0.24		55	41		1					
WQ0088	1979	Count	3	7	7	7		6	4		7					
WQ0088	1980	Average	17.1	< 12	< 12	7.82	8.05	436	529		< 7			58	70.6	0
WQ0088	1980	Std. Deviation	2.2	5	5	0.26	0.21	55	215		4			12	14.9	0
WQ0088	1980	Count	4	7	7	7	2	7	4		7			4	4	4
WQ0088	1981	Average	16.3	< 10	< 10	7.78	7.88	410	447		< 5	0.92		59	72.3	0
WQ0088	1981	Std. Deviation	3.9	0	0	0.20	0.07	51	30		0	0.14		5	5.9	0
WQ0088	1981	Count	2	6	6	6	3	6	3		6	3		6	6	6
WQ0088	1982	Average	9.5	< 10	< 10	7.86		410	477		< 5	0.68		60	72.8	0
WQ0088	1982	Std. Deviation		0	0	0.24		35			0	0.25		5	5.7	0
WQ0088	1982	Count	1	6	6	6		6	1		6	6		6	6	6
WQ0088	1983	Average	15.0	< 10	< 10	7.80		404	433		< 5	0.83		57	70.0	0
WQ0088	1983	Std. Deviation	3.0	0	0	0.44		89	71		0	0.15		1	1.4	0
WQ0088	1983	Count	3	3	3	3		3	3		3	3		3	3	3
WQ0088	1984	Average		< 10	< 10	7.77		376			< 6	0.78		66	80.5	0
WQ0088	1984	Std. Deviation		0	0	0.10		25			2	0.20		2	2.5	0
WQ0088	1984	Count		3	3	3		3			3	3		3	3	3
WQ0088	2001	Average	18.1		< 10	7.80		493		329	< 1	0.56	< 5	67	81.3	< 0.5
WQ0088	2001	Std. Deviation	2.1		0	0.34		74				0.08				
WQ0088	2001	Count	7		6	7		7		1	1	7	1	1	1	1

1. Average temperature calculated for summer time only, from June through September.

1. In 2001 total metals were analyzed where previously most analyses were for extractable metals.

a. Outlier value for specific conductivity of 1180 uS/cm from site WQ0088 in 1979 may be in error and is excluded from calculations.

Table 3. Historical and recent water quality data from two sites in Lake Athapapuskow, 1976 through 1984 and 2001 (continued).

Site	Date	Statistic	Hydroxide Alkalinity OH mg/L	Dissolved Oxygen mg/L	Total Organic Carbon C mg/L	Total Inorganic Carbon C mg/L	Nitrate - Nitrite Nitrogen N mg/L	Ammonia Nitrogen N mg/L	Total Kjeldahl Nitrogen N mg/L	Total Phosphorus mg/L as P	Ortho Phosphorus mg/L as P	Fluoride F mg/L	Chloride Cl mg/L	Sulphate SO_4 mg/L	Total Hardness $CaCO_3$ mg/L	Arsenic As Extratable mg/L	Cadmium Cd Extratable mg/L
East of Four Mile Island near Goose R.																	
WQ0089	1976	Average	0		9.1	15.8	0.05	0.07	0.4	0.020	0.020	0.11	30.6	47	132	< 0.0400	< 0.0050
WQ0089	1976	Std. Deviation	0		2.1	2.3	0.04	0.07	0.2	0.000	0.000	0.02	2.1	5	12	0.0000	0.0000
WQ0089	1976	Count	8		8	8	8	8	8	8	8	8	8	7	8	8	8
WQ0089	1977	Average	0	10.0	8.3	13.3	0.23			0.015	0.005		32.3	52	135	< 0.0117	< 0.0050
WQ0089	1977	Std. Deviation	0	0.5	1.2	4.8	0.34			0.006			1.8	19	5	0.0140	0.0000
WQ0089	1977	Count	6	5	6	6	6			6	1		6	6	6	6	6
WQ0089	1978	Average		11.2			0.21		0.4	0.059						0.0023	< 0.005
WQ0089	1978	Std. Deviation		2.0			0.40		0.2	0.115						0.0019	0.0000
WQ0089	1978	Count		7			7		7	7						7	7
WQ0089	2001	Average	< 0.5	10.4	5.2	18.0	0.04	0.04	0.5[a]	0.008			35.0	52.7	142	0.0009	0.00009
WQ0089	2001	Std. Deviation					0.04	0.02		0.003						Total[2]	Total[2]
WQ0089	2001	Count	1	1	1	1	7	7	1	7			1	1	1	1	1
Near west Bakers Narrows channel																	
WQ0088	1976	Average	0		11.9	12.8	0.07	0.08	0.5	0.023	0.020	0.12	54.5	80	168	< 0.0400	< 0.0069
WQ0088	1976	Std. Deviation	0		3.3	2.8	0.09	0.11	0.2	0.007	0.000	0.02	16.8	22	32	0.0000	0.0053
WQ0088	1976	Count	8		8	8	8	8	8	8	8	8	8	7	8	8	8
WQ0088	1977	Average	0	8.2	16.2	11.8	0.09			0.021	0.003		61.4	82	192	< 0.0108	< 0.0050
WQ0088	1977	Std. Deviation	0	3.4	19.3	1.6	0.06			0.004			4.4	5	17	0.0143	0.0000
WQ0088	1977	Count	6	5	6	6	6			5	1		6	6	6	6	6
WQ0088	1978	Average		10.9			0.07		0.4	0.023						0.0026	< 0.0050
WQ0088	1978	Std. Deviation		1.2			0.06		0.1	0.012						0.0017	0.0000
WQ0088	1978	Count		6			7		7	7						7	7
WQ0088	1979	Average		10.8			0.03		0.4	0.040						0.0023	< 0.0050
WQ0088	1979	Std. Deviation		1.2			0.02		0.1	0.054						0.0005	0.0000
WQ0088	1979	Count		7			7		7	7						7	7
WQ0088	1980	Average	0	10.8			0.02		0.4	0.033						0.0019	< 0.0050
WQ0088	1980	Std. Deviation	0	1.8			0.02		0.1	0.016						0.0007	0.0000
WQ0088	1980	Count	4	7			7		7	7						7	7
WQ0088	1981	Average	0	11.1	11.8	13.9	0.13		0.4	0.026						0.0022	< 0.0050
WQ0088	1981	Std. Deviation	0	1.4	2.4	1.7	0.26		0.1	0.015						0.0010	0.0000
WQ0088	1981	Count	6	6	6	6	6		6	5						6	6
WQ0088	1982	Average	0	10.5	10.4	12.4	0.02		0.4	0.017					197	0.0028	< 0.0050
WQ0088	1982	Std. Deviation	0	2.1	1.5	1.7	0.01		0.1	0.004						0.0013	0.0000
WQ0088	1982	Count	6	6	6	6	6		6	6					1	5	5
WQ0088	1983	Average	0	9.5	10.5	12.3	0.02		0.5	0.028						0.0013	< 0.0010
WQ0088	1983	Std. Deviation	0	0.3	3.1	1.2	0.01		0.2	0.019						0.0006	0.0000
WQ0088	1983	Count	3	3	3	3	3		3	3						3	3
WQ0088	1984	Average	0	13.5	10.8	15.2	0.02		0.4	0.014						0.0020	< 0.0010
WQ0088	1984	Std. Deviation	0	1.4	1.6	3.1	0.00		0.1	0.005						0.0017	0.0000
WQ0088	1984	Count	3	3	3	3	3		3	3						3	3
WQ0088	2001	Average	< 0.5	10.4	8	16	0.04	0.04	0.6[a]	0.016			56.8	96.1	194	0.0015	0.00014
WQ0088	2001	Std. Deviation					0.03	0.02		0.005						Total[2]	Total[2]
WQ0088	2001	Count	1	1	1	1	7	7	1	7			1	1	1	1	1

a. Total Kjeldahl nitrogen averages for 2001 were from June samples only.

Table 3. Historical and recent water quality data from two sites in Lake Athapapuskow, 1976 through 1984 and 2001 (continued).

Site	Date	Statistic	Calcium Ca Extratable mg/L	Hexavalent Chromium Cr+6 Extratable mg/L	Copper Cu Extratable mg/L	Iron Fe Extratable mg/L	Lead Pb Extratable mg/L	Magnesium Mg Extratable mg/L	Manganese Mn Extratable mg/L	Nickel Ni Extratable mg/L	Potassium K Extratable mg/L	Sodium Na Extratable mg/L	Zinc Zn Extratable mg/L
East of Four Mile Island near Goose R.													
WQ0089	1976	Average	38.1		< 0.0058	0.05	< 0.0113	8.75	< 0.0200	< 0.0313	2.03	10.0	< 0.030
WQ0089	1976	Std. Deviation	4.8		0.0049	0.04	0.0035	0.89	0.0000	0.0562	0.05	0.0	0.020
WQ0089	1976	Count	8		8	8	8	8	8	8	8	8	7
WQ0089	1977	Average	39.5		< 0.0058	0.03	< 0.0083	8.83	< 0.0200	0.0150	2.27	10.0	0.022
WQ0089	1977	Std. Deviation	1.8		0.0020	0.01	0.0026	0.75	0.0000	0.0078	0.23	0.0	0.015
WQ0089	1977	Count	6		6	6	6	6	6	6	6	6	6
WQ0089	1978	Average		< 0.02	< 0.0071		0.0064			0.0164			0.027
WQ0089	1978	Std. Deviation		0	0.0039		0.0038			0.0099			0.022
WQ0089	1978	Count		6	7		7			7			6
WQ0089	2001	Average	42.0	0.0002	0.0026	0.10	0.0002	8.93	0.0017	0.0004	1.95	11.8	0.012
WQ0089	2001	Std. Deviation	Total[2]	Total[2] Chromium	Total[2]	Total[2]	Total[2]	Total[2]	Total[2]	Total[2]	Total[2]	Total[2]	Total[2]
WQ0089	2001	Count	1	1	1	1	1	1	1	1	1	1	1
Near west Bakers Narrows channel													
WQ0088	1976	Average	53.1		< 0.0061	0.03	< 0.0113	8.50	< 0.0200	< 0.0100	2.59	19.1	< 0.081
WQ0088	1976	Std. Deviation	10.6		0.0021	0.02	0.0035	1.51	0.0000	0.0000	0.33	11.5	0.064
WQ0088	1976	Count	8		8	8	8	8	8	8	8	8	8
WQ0088	1977	Average	62.0		< 0.0057	0.02	< 0.0083	9.00	< 0.0200	0.0125	2.98	20.3	0.079
WQ0088	1977	Std. Deviation	6.1		0.0041	0.01	0.0026	0.89	0.0000	0.0082	0.25	0.8	0.036
WQ0088	1977	Count	6		6	6	6	6	6	6	6	6	6
WQ0088	1978	Average		< 0.02	< 0.0057		< 0.0064			0.0143			0.067
WQ0088	1978	Std. Deviation		0	0.0019		0.0038			0.0093			0.035
WQ0088	1978	Count		6	7		7			7			7
WQ0088	1979	Average			< 0.0079		0.0086			0.0164			0.073
WQ0088	1979	Std. Deviation			0.0057		0.0048			0.0080			0.024
WQ0088	1979	Count			7		7			7			7
WQ0088	1980	Average	59.5		0.0079		0.0071	8.17		0.0159			0.079
WQ0088	1980	Std. Deviation	4.2		0.0039		0.0027	0.29		0.0119			0.021
WQ0088	1980	Count	4		7		7	3		7			7
WQ0088	1981	Average	53.7		0.0230		0.0067	7.33		0.0140			0.092
WQ0088	1981	Std. Deviation	6.8		0.0244		0.0026	1.21		0.0086			0.044
WQ0088	1981	Count	6		6		6	6		6			6
WQ0088	1982	Average	54.3		0.0396		< 0.0050	8.53		< 0.0050			0.056
WQ0088	1982	Std. Deviation	10.8		0.0296		0.0000	0.80		0.0000			0.022
WQ0088	1982	Count	6		5		5	6		5			5
WQ0088	1983	Average	55.2		< 0.0050		< 0.0050	8.38		< 0.0050			0.047
WQ0088	1983	Std. Deviation	14.6		0.0000		0.0000	1.63		0.0000			0.021
WQ0088	1983	Count	3		3		3	3		3			3
WQ0088	1984	Average	50.0		0.0150		< 0.0050	8.46		< 0.0050			0.037
WQ0088	1984	Std. Deviation	2.1		0.0132		0.0000	0.23		0.0000			0.006
WQ0088	1984	Count	3		3		3	3		3			3
WQ0088	2001	Average	66.0	0.0003	0.0027	0.12	< 0.0001	6.99	0.0048	0.0004	2.40	15.7	0.012
WQ0088	2001	Std. Deviation	Total[2]	Total[2] Chromium	Total[2]	Total[2]	Total[2]	Total[2]	Total[2]	Total[2]	Total[2]	Total[2]	Total[2]
WQ0088	2001	Count	1	1	1	1	1	1	1	1	1	1	1

Table 4. Differences between time periods and basins of Lake Athapapuskowuskow for the most commonly sampled variables using Student's t test and P =0.05.

Basin	Years	Statistic	Temperature (Summer Only)	Bacteria Fecal Coliform Bacteria/	Bacteria *Escherichia coli* Bacteria/	pH	Specific Conductivity (Laboratory)	Turbidity	Secchi Disc	Nitrate - Nitrite Nitrogen N	Ammonia Nitrogen N	Total Phosphorus	Particulate Phosphorus	Dissolved Phosphorus	Ortho Phosphorus	Chlorophyll *a*
Units			Degrees C	100mL	100mL	pH units	uS/cm	NTU	m	mg/L	mg/L	mg/L as P	mg/L as P	mg/L as P	mg/L as P	ug/L
Big Athapapuskow	1976-1978	Average	14.71	10		8.03	330	1.41		0.1514	0.0700	0.0317			0.0183	
Big Athapapuskow	1976-1978	Std. Deviation	3.73	0.00		0.12	16.89	2.49		0.2902	0.0661	0.0662			0.0050	
Big Athapapuskow	1976-1978	Count	7	21		21	21	14		21	8	21			9	
Big Athapapuskow	2001	Average	17.62	10	10	7.80	339	0.58	5.39	0.0302	0.0471	0.0080	0.0036	0.0048		0.64
Big Athapapuskow	2001	Std. Deviation	2.55	0.00	2.18	0.31	16.00	0.22	0.84	0.0321	0.0280	0.0020	0.0019	0.0015		0.41
Big Athapapuskow	2001	Count	21	21	21	21	21	21	21	21	21	21	21	21		21
Big Athapapuskow	1976-1978/	Student's t Test[2]	-2.5145	0.0000		3.1664	-1.9525	1.6970		1.6491	0.6505	5.1089				
Big Athapapuskow	2001	Pooled df	26	40		40	40	33		40	27	40				
Big Athapapuskow		Significance @ P	Increase	No Change		Decrease	No Change	No Change		No Change	No Change	Decrease				
Little Athapapuskow	1970-1984	Average	15.80	10		7.82	433	1.19		0.0542	0.0775	0.0258			0.0181	
Little Athapapuskow	1970-1984	Std. Deviation	3.60	1.90		0.24	58.20	1.72		0.0991	0.1078	0.0223			0.0057	
Little Athapapuskow	1970-1984	Count	20	53		53	52	29		53	8	51			9	
Little Athapapuskow	2001	Average	18.00	10	10	7.74	479	0.61	3.38	0.0311	0.0439	0.0171	0.0090	0.0081		1.75
Little Athapapuskow	2001	Std. Deviation	2.32	1.58	3.16	0.34	95.09	0.51	0.57	0.0376	0.0187	0.0049	0.0041	0.0026		0.74
Little Athapapuskow	2001	Count	49	40	40	49	49	49	49	49	49	49	49	49		48
Little Athapapuskow	1976-1984/	Student's t Test[2]	-3.2986	-0.0686		1.3456	-3.1173	3.2647		-0.9100	0.7472	3.2799				
Little Athapapuskow	2001	Pooled df	67	91		100	99	76		100	55	96				
Little Athapapuskow		Significance @ P	Increase	No Change		No Change	Increase	Decrease		No Change	No Change	Decrease				
Big Athapapuskow	1976-1978	Average	14.71	10		8.03	330	1.41		0.1514	0.0700	0.0317			0.0183	
Big Athapapuskow	1976-1978	Std. Deviation	3.73	0.00		0.12	16.89	2.49		0.2902	0.0661	0.0662			0.0050	
Big Athapapuskow	1976-1978	Count	7	21		21	21	14		21	8	21			9	
Little Athapapuskow	1970-1984	Average	15.80	10	10	7.82	433	1.19		0.0542	0.0775	0.0258			0.0181	
Little Athapapuskow	1970-1984	Std. Deviation	3.60	1.90	1.79	0.24	58.20	1.72		0.0991	0.1078	0.0223			0.0057	
Little Athapapuskow	1970-1984	Count	20	53	53	53	52	29		53	8	51			9	
Big Athapapuskow/	1970-1984/	Student's t Test[2]	-0.6882	-0.6268		3.8469	-8.4339	-0.3683		2.2576	0.0855	-0.9432			0.2174	
Little Athapapuskow	1976-1978	Pooled df	25	72		72	71	41		72	14	70			16	
		Significance @ P	No Change	No Change		Decrease	Increase	No Change		Decrease	No Change	No Change			No Change	
Big Athapapuskow	2001	Average	17.62	10	10	7.80	339	0.58	5.39	0.0302	0.0471	0.0080	0.0036	0.0048		0.64
Big Athapapuskow	2001	Std. Deviation	2.55	0.00	2.18	0.31	16.00	0.22	0.84	0.0321	0.0280	0.0020	0.0019	0.0015		0.41
Big Athapapuskow	2001	Count	21	21	21	21	21	21	21	21	21	21	21	21		21
Little Athapapuskow	2001	Average	18.00	10	10	7.74	479	0.61	3.38	0.0311	0.0439	0.0171	0.0090	0.0081		1.75
Little Athapapuskow	2001	Std. Deviation	2.32	1.58	3.16	0.34	95.09	0.51	0.57	0.0376	0.0187	0.0049	0.0041	0.0026		0.74
Little Athapapuskow	2001	Count	49	40	40	49	49	49	49	49	49	49	49	49		48
Big Athapapuskow/	2001	Student's t Test[2]	-0.8834	0.0000	-0.7217	0.7222	-7.2902	-0.4840	11.6139	-0.1707	0.0898	-11.3851	-7.3439	-8.2628		-8.1848
Little Athapapuskow	2001	Pooled df	68	59	59	68	68	68	68	68	68	68	68	68		67
		Significance @ P	No Change	No Change	No Change	No Change	Increase	No Change	Decrease[1]	No Change	No Change	Increase	Increase	Increase		Increase

1. Decrease in Secchi disk depth from the main basin (Big Athapapuskow) to the smaller upstream basin (Little Athapapuskow) due mainly to deeper water occurring in the main basin not to real differences in turbidity.

2. *t* value calculated on Logged values except for pH which is already based on logs.

Table 5. Variables with objectives based on Williamson (2001) with highlighted objectives used in the CCME Water Quality Index.

Variable	Units	Unlisted or Explanation	Drinking Water (D)	Recreation (R)	Aquatic Life (A)	Irrigation (I)	Greenhouse (GI)	Field Crop (FI)	Livestock (L)	Other
Bacteria										
Fecal Coliform	Bactena/100 mL		Treat to 0	200						
E-Coli	Bactena/100 mL		Treat to 0	200						
Temperature	°C		15 Aesthetic		Calculated					
pH	pH Units		Treat to 6.5-8.5	5.0-9.0	6.5-9.0					
Specific Conductivity	uS/cm		700				1000	1500	4300	
Solids										
Total Dissolved	mg/L		500 Aesthetic				700	1000	3000	
Total Suspended	mg/L				5 for background < 25 (30 day average) 25 for background ≥ 250 (1 day average)					
Turbidity	NTU		5 Aesthetic & treat to 1							
Transparency										
Secchi Disc	m	Unlisted								
True Colour	Colour Units		15 Aesthetic							
Alkalinity										
Total Alkalinity	mg/L									
Bicarbonate	mg/L	Unlisted								
Carbonate	mg/L	Unlisted								
Hydroxide	mg/L	Unlisted								
Oxygen	mg/L									
Dissolved Oxygen	mg/L	Cool water aquatic life 3 to 6 dependant on duration & temperature.			5 instantaneous minimum for early life stages.					
Oxygen Saturation	%				0.47%					
BOD	mg/L	Listed for effluent but not ambient waters								
Nitrogen										
Total Ammonia	mg/L				Calculated				100	
Nitrate-Nitrite	mg/L		10							
Kjeldahal Nitrogen	mg/L	Unlisted								
Phosphorus										
Total P	mg/L	Objective under review. Promotes nuisance algae or rooted plant growth.								0.05 in rivers & 0.025 in lakes Aesthetic (Williamson 1988)
Particulate P	mg/L	Unlisted								
Dissolved P	mg/L	Unlisted								
Chlorophyll a	ug/L	Unlisted								
Carbon										
Total C	mg/L	Unlisted								
Total Inorganic C	mg/L	Unlisted								
Total Organic C	mg/L	Unlisted								
Chloride	mg/L		250 Aesthetic				100	700	1000	
Sulphate	mg/L		500 Aesthetic							
Hardness	mg/L		200 Aesthetic (Williamson 1988)						1000	
Calcium	mg/L									
Magnesium	mg/L	Unlisted								
Potassium	mg/L	Unlisted								
Sodium	mg/L		200 Aesthetic				4	6		
Sodium Adsorbtion Ratio	SAR									
Trace Elements										
Aluminum	mg/L				0.1 > 6.5 pH, 0.005 < 6.5 pH	5.0			0.5	
Arsenic	mg/L	Aquatic life 4 day & 1 hr	0.025		0.15 & 0.34		0.1		0.25	
Antimony	mg/L		0.006							
Barium	mg/L		1000							
Beryllium	mg/L	Unlisted								
Bismuth	mg/L	Unlisted								
Boron	mg/L		5.0				0.5	6.0	5.0	

Table 5. Variables with objectives based on Williamson (2001) with highlighted objectives used in the CCME Water Quality Index.

Variable	Units	Unlisted or Explanation	Drinking Water (D)	Recreation (R)	Aquatic Life (A)	Irrigation (I)	Greenhouse (GI)	Field Crop (FI)	Livestock (L)	Other
Bacteria										
Fecal Coliform	Bacteria/100 mL		Treat to 0	[redacted]						
E-Coli	Bacteria/100 mL		Treat to 0	200						
Temperature	°C		15 Aesthetic		Calculated					
pH	pH Units		Treat to 6.5-8.5	5.0-9.0	[redacted]					
Specific Conductivity	uS/cm		700				[redacted]	1500	4300	
Solids										
Total Dissolved	mg/L		500 Aesthetic				700	1000	3000	
Total Suspended	mg/L				5 for background < 25 (30 day average) [redacted] 250 (1 day average)					
Turbidity	NTU		5 Aesthetic & treat to 1							
Transparency										
Secchi Disc	m	Unlisted								
True Colour	Colour Units		15 Aesthetic							
Alkalinity										
Total Alkalinity	mg/L									
Bicarbonate	mg/L	Unlisted								
Carbonate	mg/L	Unlisted								
Hydroxide	mg/L	Unlisted								
Oxygen	mg/L									
Dissolved Oxygen	mg/L	Cool water aquatic life 3 to 6 dependant on duration & temperature.			[redacted] mum for early life stages.					
Oxygen Saturation	%				0.47%					
BOD	mg/L	Listed for effluent but not ambient waters								
Nitrogen										
Total Ammonia	mg/L				[redacted]				100	
Nitrate-Nitrite	mg/L		[redacted]							
Kjeldahal Nitrogen	mg/L	Unlisted								
Phosphorus										
Total P	mg/L	Objective under review. Promotes nuisance algae or rooted plant growth.								[redacted] Aesthetic (Williamson 1988)
Particulate P	mg/L	Unlisted								
Dissolved P	mg/L	Unlisted								
Chlorophyll a	ug/L	Unlisted								
Carbon										
Total C	mg/L	Unlisted								
Total Inorganic C	mg/L	Unlisted								
Total Organic C	mg/L	Unlisted								
Chloride	mg/L		250 Aesthetic				100	700	1000	
Sulphate	mg/L		500 Aesthetic							
Hardness	mg/L		200 Aesthetic (Williamson 1988)						1000	
Calcium	mg/L									
Magnesium	mg/L	Unlisted								
Potassium	mg/L	Unlisted								
Sodium	mg/L		200 Aesthetic				4	6		
Sodium Adsorbtion Ratio	SAR									
Trace Elements										
Aluminum	mg/L			0.1 > 6.5 [redacted]		5.0			0.5	
Arsenic	mg/L	Aquatic life 4 day & 1 hr [redacted]			0.15 & 0.34			0.1	0.25	
Antimony	mg/L		0.006							
Barium	mg/L		1000							
Beryllium	mg/L	Unlisted								
Bismuth	mg/L	Unlisted								
Boron	mg/L		5.0				0.5	6.0	5.0	

Table 5. Variables with objectives based on Williamson (2001) with highlighted objectives used in the CCME Water Quality Index (continued).

Variable	Units	Unlisted or Explanation	Drinking Water (D)	Recreation (R)	Aquatic Life (A)	Irrigation (I)	Greenhouse (GI)	Field Crop (FI)	Livestock (L)	Other
Cadmium	mg/L		0.005			0.0051			0.08	
Chromium	mg/L		0.05							
Hexavalent Chromium	mg/L				0.011 & 0.016	0.008			0.05	
Cobalt	mg/L					0.05			0.1	
Copper	mg/L	Aquatic life dissolved	1.0 Aesthetic				0.02	0.1	0.5-5.0	
Cesium	mg/L	Available for radio isotopes only								
Iron	mg/L				0.3	5.0				
Lead	mg/L		0.01			0.2				
Lithium	mg/L					2.5				
Manganese	mg/L					0.2				
Molybdenum	mg/L				0.073		0.01	0.05	0.5	
Nickel	mg/L					200			1000	
Rubidium	mg/L	Unlisted								
Selenium	mg/L		0.01		0.001		0.02	0.05	0.05	
Silver	mg/L		0.0001							
Strontium	mg/L	Available for radio isotopes only								
Telurium	mg/L	Unlisted								
Thallium	mg/L		0.0008							
Tin	mg/L	Unlisted								
Titanium	mg/L	Unlisted								
Tungsten	mg/L	Unlisted								
Uranium	mg/L		0.1			0.01			0.2	
Vanadium	mg/L	Unlisted				0.1			0.1	
Zinc	mg/L		5.0 Aesthetic				1.0	5.0	5.0	
Zirconium	mg/L	Available for radio isotopes only								
Pesticides										
2, 4-D	ug/L		100						100	
2, 4-DB	ug/L		100		4				100	
2, 4-DP	ug/L		100		4				100	
2, 4, 5-T	ug/L				4				100	
2, 4, 5-TP	ug/L				4				100	
Alachlor	ug/L	Unlisted								
Aldrin	ug/L		0.7							
Atrazine	ug/L		5			10			5	
Azinphos-Methyl	ug/L		20							
Bromacil	ug/L		5			0.2			1100	
Bromoxynil	ug/L		5		5				11	
Carbofuran	ug/L		90		1.8				45	
Cis-Chlordane	ug/L	Sediment concentrations only								
Trans-Chlordane	ug/L	Sediment concentrations only								
Chlorpyrifos-ethyl	ug/L		90		0.0035				24	
Chlorothalonil	ug/L				0.18	5.8			170	
DDD p,p	ug/L	Sediment concentrations only								
DDE p,p	ug/L	Sediment concentrations only								
DDT p,p	ug/L	Sediment concentrations only								
Deltamethrin	ug/L				0.004				2.5	
Diazinon	ug/L		2.5							
Dicamba	ug/L		120		10				122	
Diclofop	ug/L	See Diclofop-Methyl								
Diclofop-Methyl	ug/L		9		6.1	0.18			9	
Dieldrin	ug/L		0.7							
Dimethoate	ug/L		20		6.2				3	
Dinoseb	ug/L		10		0.05	16			150	

Table 5. Variables with objectives based on Williamson (2001) with highlighted objectives used in the CCME Water Quality Index (continued).

Variable	Units	Unlisted or Explanation	Drinking Water (D)	Recreation (R)	Aquatic Life (A)	Irrigation (I)	Greenhouse (GI)	Field Crop (FI)	Livestock (L)	Other
Endosulfan I	ug/L				0.02					
Endrin	ug/L	Sediment concentrations only								
Eptam	ug/L	Unlisted								
Ethfluralin	ug/L	Unlisted								
Fenoxaprop	ug/L				4				100	
Glyphosate	ug/L		280		65				280	
(HCH Alpha)	ug/L	Sediment concentrations only								
HCH Beta	ug/L	Sediment concentrations only								
HCH Delta	ug/L	Sediment concentrations only								
Lindane (HCH Gamma)	ug/L	Sediment concentrations only			[redacted]					
Heptachlor	ug/L	Sediment concentrations only								
Heptachlor-Epoxide	ug/L	Sediment concentrations only								
Imazethabenz	ug/L	Unlisted								
Malathion	ug/L		190						25	
MCPA	ug/L				2.6	[redacted]			100	
Mecoprop	ug/L				4					
Methoxychlor p,p	ug/L		900						80	
Metribuzin	ug/L		80		1.0	0.5				
Metsulfuron-Methyl	ug/L	Unlisted								
Mirex	ug/L	Unlisted								
Parathion-Ethyl	ug/L	for Total Parathion	50							
Parathion-Methyl	ug/L	for Total Parathion	50							
Pentachlorophenol	ug/L		30 Aesthetic, 60 Health		0.5				190	
Picloram	ug/L		190		29					
Propachlor	ug/L	Unlisted								
Propanil	ug/L	Unlisted								
Propoxur	ug/L	Unlisted							100	
Quizlofop	ug/L				4				10	
Simazine	ug/L		10		[redacted]	10				
Terbufos	ug/L		1							
Tifensulfuron	ug/L	Unlisted								
Trialtate	ug/L				0.24				230	
Tribenuron	ug/L	Unlisted								
Triclopyr	ug/L	Unlisted								
Trifluralin	ug/L		45		[redacted]				45	
Other										
Total Phenols	mg/L				0.004				0.002	

Table 5. Variables with objectives based on Williamson (2001) with highlighted objectives used in the CCME Water Quality Index (continued).

Variable	Units	Unlisted or Explanation	Drinking Water (D)	Recreation (R)	Aquatic Life (A)	Irrigation (I)	Greenhouse (GI)	Field Crop (FI)	Livestock (L)	Other
Cadmium	mg/L		0.005		Calculated	0.0051			0.08	
Chromium	mg/L		0.05							
Hexavalent Chromium	mg/L				0.011 & 0.016	0.008			0.05	
Cobalt	mg/L					0.05			0.1	
Copper	mg/L	Aquatic life disssolved	1.0 Aesthetic		Calculated		0.02	0.1	0.5-5.0	
Cesium	mg/L	Available for radio isotopes only								
Iron	mg/L		0.3 Aesthetic		0.3	5.0				
Lead	mg/L		0.01		Calculated	0.2				
Lithium	mg/L					2.5				
Manganese	mg/L		0.05 Aesthetic			0.2				
Molybdenum	mg/L				0.073		0.01	0.05	0.5	
Nickel	mg/L				Calculated	200			1000	
Rubidium	mg/L	Unlisted								
Selenium	mg/L		0.01		0.001		0.02	0.05	0.05	
Silver	mg/L		0.0001							
Strontium	mg/L	Available for radio isotopes only								
Telurium	mg/L	Unlisted								
Thallium	mg/L		0.0008							
Tin	mg/L	Unlisted								
Titanium	mg/L	Unlisted								
Tungsten	mg/L	Unlisted								
Uranium	mg/L		0.1			0.01			0.2	
Vanadium	mg/L	Unlisted				0.1			0.1	
Zinc	mg/L		5.0 Aesthetic		Calculated		1.0	5.0	5.0	
Zirconium	mg/L	Available for radio isotopes only								
Pesticides										
2, 4-D	ug/L		100		4				100	
2, 4-DB	ug/L		100		4				100	
2, 4-DP	ug/L		100		4				100	
2, 4, 5-T	ug/L				4				100	
2, 4, 5-TP	ug/L				4				100	
Alachlor	ug/L	Unlisted								
Aldrin	ug/L		0.7							
Atrazine	ug/L		5		1.8	10			5	
Azinphos-Methyl	ug/L		20							
Bromacil	ug/L		5			0.2			1100	
Bromoxynil	ug/L		5		5	0.33			11	
Carbofuran	ug/L		90		1.8				45	
Cis-Chlordane	ug/L	Sediment concentrations only								
Trans-Chlordane	ug/L	Sediment concentrations only								
Chlorpyrifos-ethyl	ug/L		90		0.0035				24	
Chlorothalonil	ug/L				0.18	5.8			170	
DDD p,p	ug/L	Sediment concentrations only								
DDE p,p	ug/L	Sediment concentrations only								
DDT p,p	ug/L	Sediment concentrations only								
Deltamethrin	ug/L				0.004				2.5	
Diazinon	ug/L		2.5							
Dicamba	ug/L		120		10	0.006			122	
Diclofop	ug/L	See Diclofop-Methyl								
Diclofop-Methyl	ug/L		9		6.1	0.18			9	
Dieldrin	ug/L		0.7							
Dimethoate	ug/L		20		6.2				3	
Dinoseb	ug/L		10		0.05	16			150	

Table 5. Variables with objectives based on Williamson (2001) with highlighted objectives used in the CCME Water Quality Index (continued).

Variable	Units	Unlisted or Explanation	Drinking Water (D)	Recreation (R)	Aquatic Life (A)	Irrigation (I)	Greenhouse (GI)	Field Crop (FI)	Livestock (L)	Other
Endosulfan I	ug/L				0.02					
Endrin	ug/L	Sediment concentrations only								
Eptam	ug/L	Unlisted								
Ethfluralin	ug/L	Unlisted								
Fenoxaprop	ug/L				4				100	
Glyphosate	ug/L		280		65				280	
(HCH Alpha)	ug/L	Sediment concentrations only								
HCH Beta	ug/L	Sediment concentrations only								
HCH Delta	ug/L	Sediment concentrations only								
Lindane (HCH Gamma)	ug/L	Sediment concentrations only			0.06 (Williamson 1988)					
Heptachlor	ug/L	Sediment concentrations only								
Heptaclor-Epoxide	ug/L	Sediment concentrations only								
Imazethabenz	ug/L	Unlisted								
Malathion	ug/L		190		2.6	0.028			25	
MCPA	ug/L				4				100	
Mecoprop	ug/L									
Methoxychlor p,p	ug/L		900						80	
Metribuzin	ug/L		80		1.0	0.5				
Metsulfuron-Methyl	ug/L	Unlisted								
Mirex	ug/L	Unlisted								
Parathion-Ethyl	ug/L	for Total Parathion	50							
Parathion-Methyl	ug/L	for Total Parathion	50							
Pentachlorophenol	ug/L		30 Aesthetic, 60 Health		0.5					
Picloram	ug/L		190		29				190	
Propachlor	ug/L	Unlisted								
Propanil	ug/L	Unlisted								
Propoxur	ug/L	Unlisted								
Quizlofop	ug/L				4				100	
Simazine	ug/L		10		0.5	10			10	
Terbufos	ug/L		1							
Tifensulfuron	ug/L	Unlisted								
Triallate	ug/L				0.24				230	
Tribenuron	ug/L	Unlisted								
Triclopyr	ug/L	Unlisted								
Trifluralin	ug/L		45		0.2				45	
Other										
Total Phenols	mg/L				0.004				0.002	

total ammonia), and nitrate-nitrite nitrogen. Phosphorus often limits algae growth since it is likely to be the least abundant nutrient in northern lakes. During 2001, the average total phosphorus in the main basin of Lake Athapapuskow was significantly lower than that in the Little Athapapuskow portion of the lake. Average total phosphorus in the main basin of Lake Athapapuskow was very low at 0.008 mg/L (Table 1). Average total phosphorus was generally more than twice as high in the north basin and ranged between an average of 0.015 and 0.021 mg/L. However, these were still relatively low and there were only three excursions over the 0.025 mg/L objective for lakes, beyond which there is potential for nuisance algae blooms in lakes (Table 5 and Appendix 1). Both basins showed a significant decrease in total phosphorus since the 1970s and 1980s (Table 4). Total phosphorus was lowest during July and August. In this case the dissolved phosphorus was higher in June and particulate phosphorus was higher in September (Figure 2). The highest average total and total dissolved phosphorus occurred at site WQ2799 (located between an island and the east shore of Little Athapapuskow Lake) (Figures 1 and 2). Some of the dissolved phosphorus may have been contributed from the local cottage and housing development but may be due mainly to natural conditions prevailing in the area. The second highest average total particulate phosphorus also occurred at this site, likely due mainly to the shallowness of the location where re-suspension of sediment into the water column may occur more frequently due to wave action or boating activity.

Total ammonia, and nitrate-nitrite were present in low concentrations in Lake Athapapuskow (Table 1, Figure 3, and Appendix 1). High ammonia nitrogen levels can potentially kill fish but ammonia concentrations in all samples were very low and well below their calculated objectives. Nitrate-nitrite nitrogen was frequently at less than detectable levels and more than three orders of magnitude lower than the objective for human health of 10 mg/L.

Turbidity

Turbidity rises with increases in suspended particulate material (total suspended solids). The average turbidity in Lake Athapapuskow was very low at less than one NTU in any one month (Table 1, and Figure 4). The turbidity in Little Athapapuskow Lake actually showed a significant decrease from the turbidity in the 1970s and 1980s.

Secchi disk transparency provides an estimate of water clarity. Secchi disk measurements were only available for 2001. In the larger deeper basin of Lake Athapapuskow where Secchi disk depths were excellent with averages per site ranging from 5.0 to 5.9 m. In the smaller shallower northern basin average Secchi disk depths ranged from 3.1 to 4.1 m. This still showed good water clarity especially since at some of the shallower sites in this basin the lake bottom could be seen and the Secchi disk depth would have underestimated water clarity. It is likely therefore, that the statistical difference ($\alpha = 0.05$) between the north and south basins was mainly due to shallower total depths in the north basin, particularly since there was no significant difference in turbidity between basins in 2001 (Table 4).

Chlorophyll *a*

Chlorophyll *a* is a green pigment contained in growing plant tissue and was only measured in 2001. Chlorophyll *a*, when extracted from algae contained in a water sample, can be used as a relative measure of the extent of algae growth. It was low in both basins but average chlorophyll *a* in the larger main basin of Lake Athapapuskow was 0.64 µg/L, significantly lower than the average chlorophyll *a* of 1.75 µg/L in the Little Athapapuskow Lake area (Table 4, and Figure 5). Again, this was likely to be partly due to the shallower depths and warmer temperatures in the smaller northern basin especially since some of the sites in this basin were shallower than the potential euphotic zone depth.

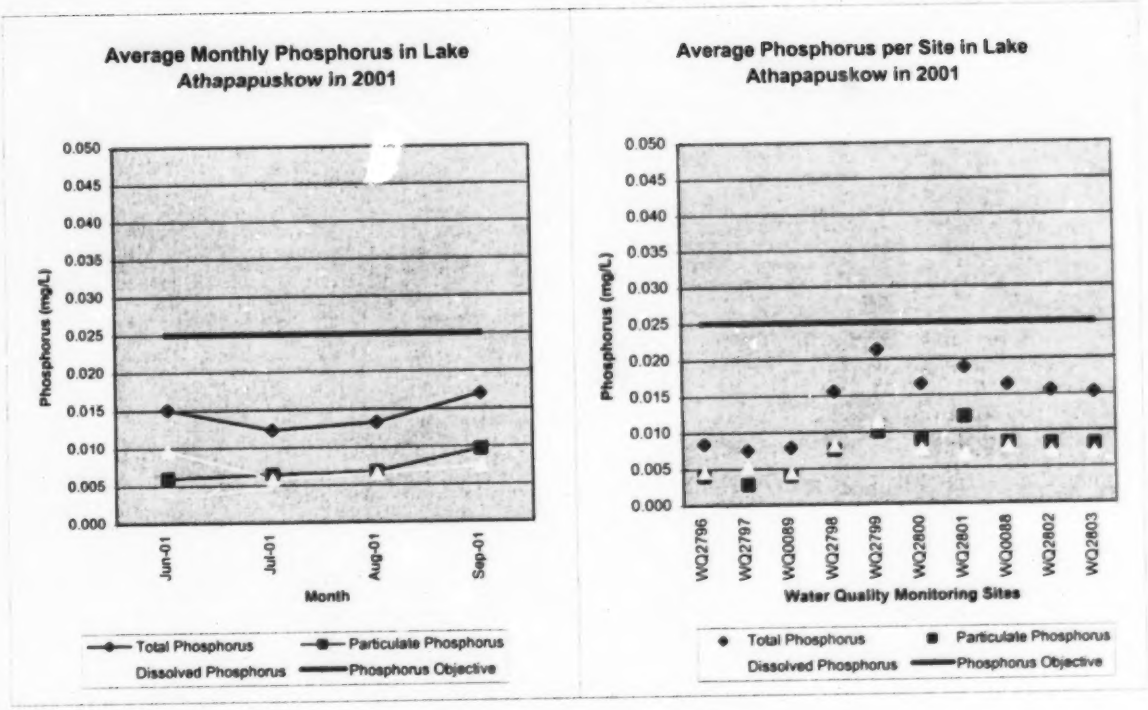

Figure 2. Average total, particulate, and dissolved phosphorus, Lake Athapapuskow in 2001.

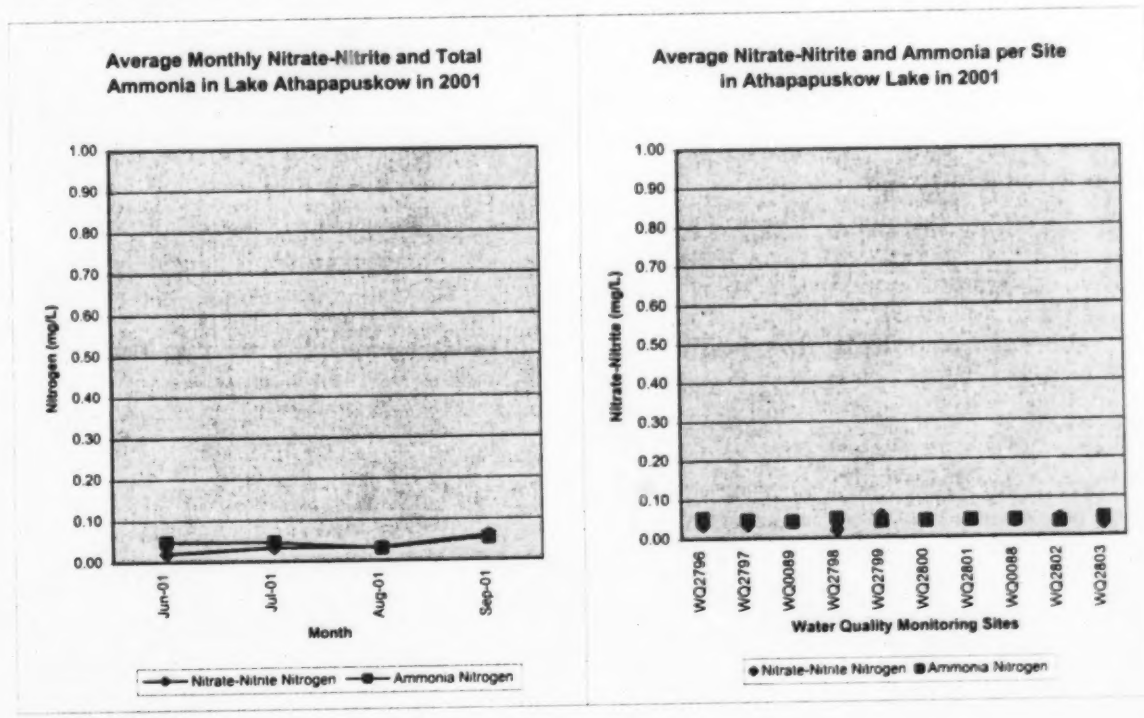

Figure 3. Average nitrate-nitrite, and ammonia nitrogen, Lake Athapapuskow in 2001.

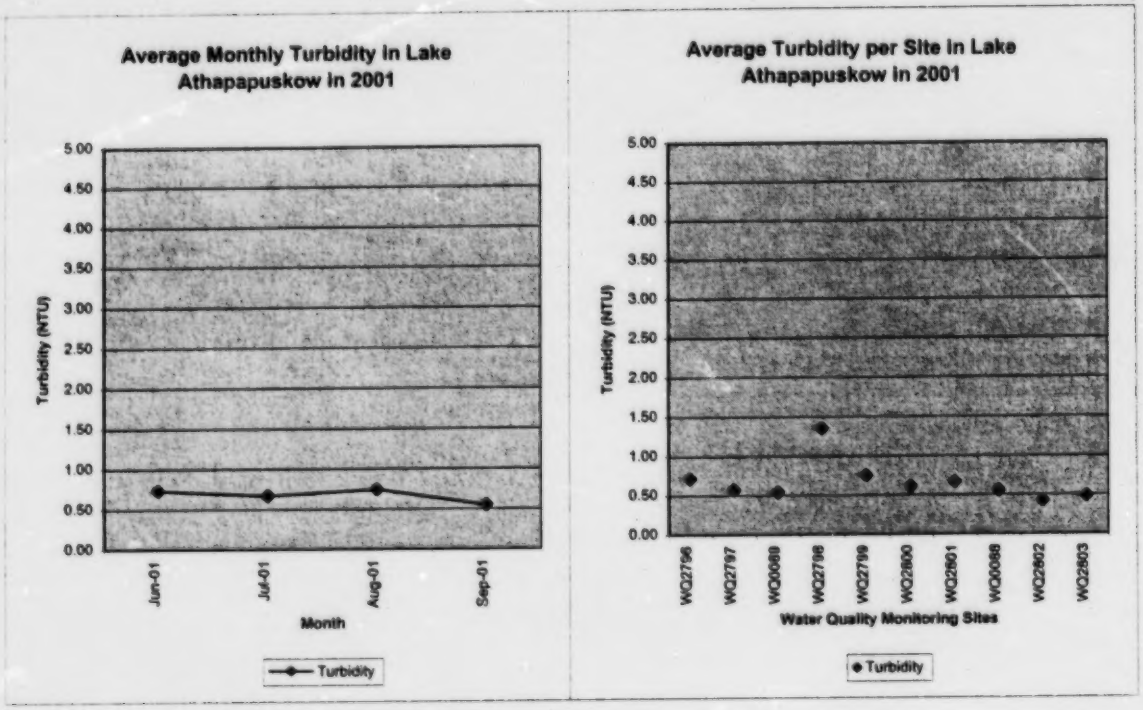

Figure 4. Average turbidity, Lake Athapapuskow in 2001.

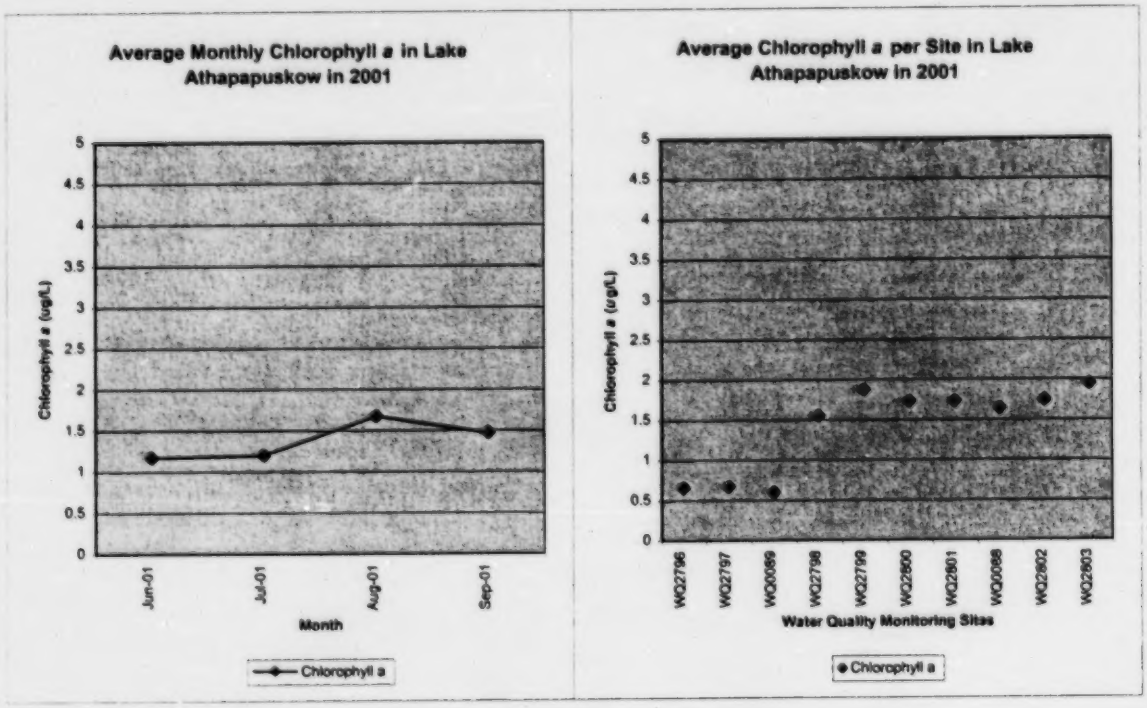

Figure 5. Average chlorophyll a, Lake Athapapuskow in 2001.

Fecal Coliform Bacteria

Fecal coliform bacteria including *Escherichia coli* counts were near or less than the detection limit of 10 organisms/100 mL of water in Lake Athapapuskow over the summer of 2001 (Appendix 1). All the fecal coliform bacteria counts were well below the recommended objective for recreational water quality of 200 organisms/100 mL (Williamson 1988, 2001). Fecal coliform bacteria were also well below this objective in the 1970s and 1980s as well (Appendix 2). There were no significant differences ($\alpha = 0.05$) between basins or over time. However, as with all surface waters, water from the lake should always be boiled or disinfected before it is used for drinking.

pH

During the summer of 2001, the pH values in Lake Athapapuskow ranged from 7.01 to 8.28 in 2001 well within the any of recommended objectives for pH (Table 5 and Appendix 1). The pH values were within the objective range of 6.5 and 9.0 recommended for the protection of aquatic life (Williamson 1988, 2001). This was also the case with pH in the 1970s and 1980s where the range was 7.20 to 8.25. During 2001, pH was similar in both basins (Figure 6). Also, there was no difference between north basin pH when comparing the 1970s and 1980s to 2001. However, the pH in the main south basin was significantly higher ($\alpha = 0.05$) in the 1970s than it was in either basin in 2001 or the north basin in the 1970s and 1980s.

Specific Conductivity

Specific conductivity is a measure of the dissolved salts in water and is closely related to total dissolved solids. Three conductivity measurements including one from 2001 and two from historical data appeared anomalous and were excluded from data ranges and calculations (Appendices 1 and 2). Laboratory measured conductivity data for Lake Athapapuskow was still quite variable and ranged from 310 to 601 µS/cm in 2001 relative to 302 to 525 µS/cm between 1976 and 1984 (Appendices 1 and 2). Field conductivity measured between 1976 and 1984 ranged from 290 to 600 µS/cm, similar to the 2001 laboratory measured conductivity (Appendices 1 and 2). These were well below the recommended objective of 1000 µS/cm (Williamson 1988, 2001). However, average specific conductivity was markedly higher at sites located between Bakers Narrows and Mink Narrows where Little Athapapuskow Lake empties into the main basin of Lake Athapapuskow during 2001 (Figure 7). The Little Athapapuskow Lake area historically tended to have higher conductivities than the main basin of Lake Athapapuskow. However, there were significant increases over time ($\alpha = 0.05$) in laboratory measured conductivity in the Little Athapapuskow Lake area for samples collected between 1976 and 1984 relative to samples collected in 2001, while there was no difference between time periods for the main basin of Lake Athapapuakow (Table 4). When comparing the main basin of Lake Ahapapuskow to the Little Athapapuskow Lake area there was a significant increase in conductivity between the larger and smaller basins, both for data collected between 1976 and 1984 and data collected in 2001. The average conductivity in the Schist Creek Bay area (WQ2800) was the highest at any site in 2001. This may indicate some influence from drainage down Schist Creek since historically the conductivity, total dissolved solids, and ions such as chloride, sodium, and calcium tend to be higher at the outlet of Schist Lake than in Lake Athapapuskow. However, three other sites in the area showed similar average conductivities and two of them were upstream of the site in question (Figures 1 and 7). Therefore some influence from runoff from the local cottage and residential lots and roadways also appears likely.

Water Quality on June 25 and June 26, 2001

Results for over 100 variables measured in water samples collected on June 25 and 26, 2001 are shown in Table 2 and Appendix 1 for Lake Athapapuskow. Of these, 25 variables were used to calculate the CCME Water Quality Index (CCME WQI) for Lake Athapapuskow. Variables used in this index

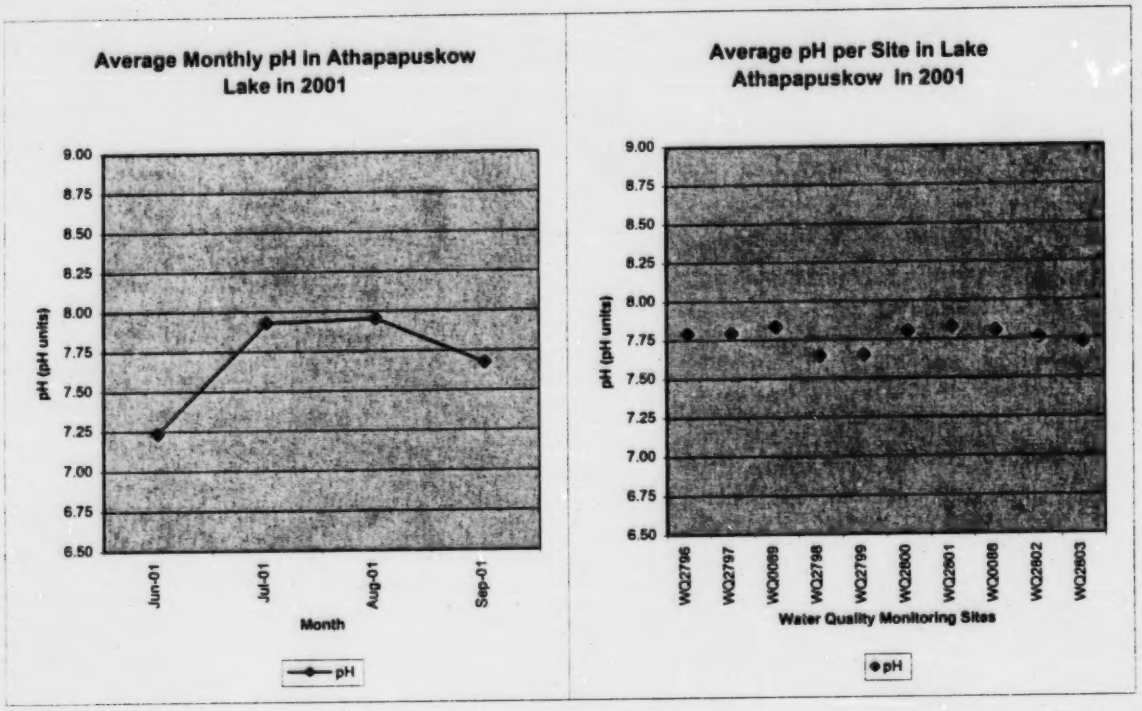

Figure 6. Average pH, Lake Athapapuskow in 2001.

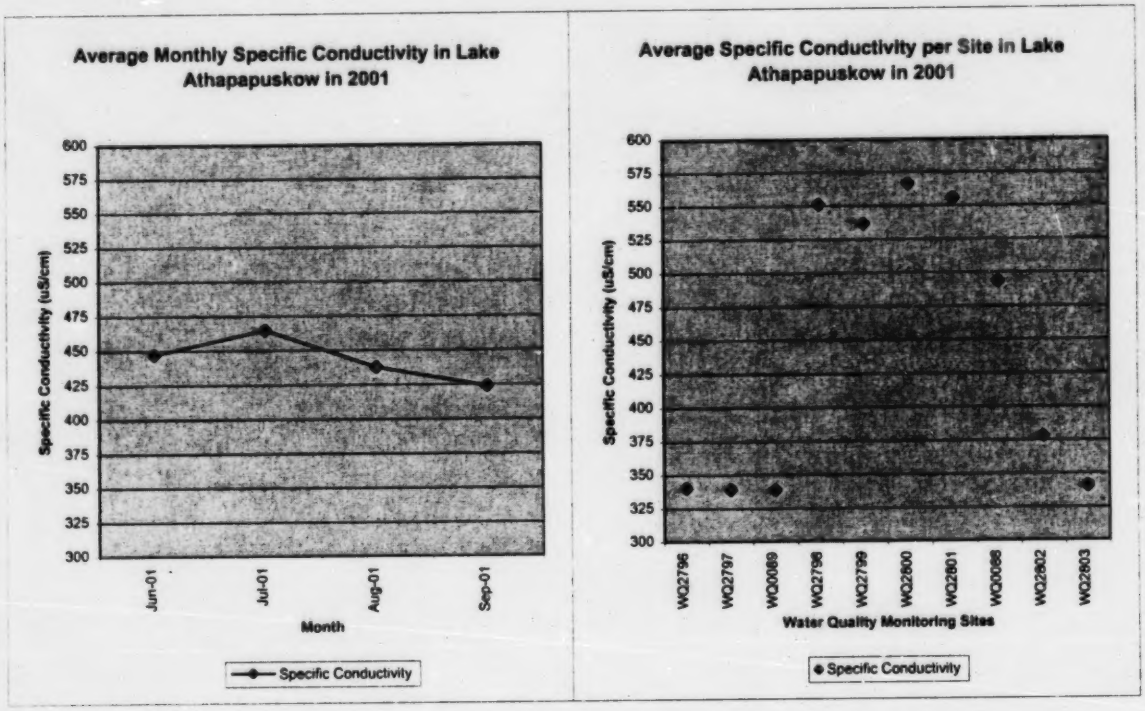

Figure 7. Average specific conductivity, Lake Athapapuskow in 2001.

included total phosphorus, un-ionized ammonia, fecal coliform bacteria, pH and specific conductivity that have already been discussed. The following is a discussion of other variables that were also used.

Total suspended solids (TSS) in Lake Athapapuskow on June 25 and 26, 2001 ranged from < 1 to 12 mg/L (Table 2). These were well below the objective of 25 mg/L used for the CCME WQI (Tables 5 and 6 and Williamson 1988, 2001). It is unlikely that suspended solids would have exceeded the objective during the remainder of the summer since the turbidity never exceeded 3.8 NTU (Appendix 1).

Dissolved oxygen is essential to the survival of fish stocks. Dissolved oxygen concentrations ranged from 9.8 to 10.4 mg/L (Table 2). These dissolved oxygen concentrations were well over the 5 mg/L objective recommended for the maintenance of cool water aquatic life (Table 6 and Williamson 1988, 2001).

Trace element analyses from water samples collected from Lake Athapapuskow on June 25, and June 26, 2001 included total concentrations of cadmium, copper, nickel, lead, zinc, arsenic, and dissolved aluminum. In Lake Athapapuskow, total lead concentrations were all near or below detection limits and these as well as arsenic, copper, cadmium, nickel, and zinc were all well below their lowest respective objectives (Tables 2, 5 and 6 and Williamson 1988, 2001). The objective for aluminum is dependent on pH and in all cases the objective was 0.1 mg/L. There were no excursions of this objective for either total or dissolved aluminum in Lake Athapapuskow.

Iron and manganese are of an aesthetic concern in drinking water but can be removed with treatment. Total iron and manganese concentrations were well below recommended objectives of 0.3 and 0.05 mg/L, respectively (Tables 2, 5 and 6, and Williamson 1988, 2001).

Pesticide analyses were conducted on water samples collected from Lake Athapapuskow on June 22, 2000. None of the 39 pesticides tested for were detected (Tables 2).

The CCME Water Quality Index (CCME WQI) for Lake Athapapuskow was based on 25 variables that have been previously discussed. Figure 8 shows the CCME WQI rating for Lake Athapapuskow as well as five other northern Manitoba lakes including: Snow, Setting, Rocky, Paint, Liz, and Clearwater lakes. These indices indicated "Excellent" water quality for all five lakes with CCME WQI falling in the range of 95 to 100 (Table 6). Lake Athapapuskow rated 98, better than all the other lakes except for Liz Lake. This was an "Excellent" score due to only three excursions, all for total phosphorus in this case (Table 6 and Appendix 1). The only lake that rated a perfect score of 100 was Liz Lake in 1998, where there were no excursions beyond any of the 25 objectives.

A water quality index rating of "Excellent" indicates that:

- all water uses are protected, with a virtual absence of impairment or only a minimal degree of impairment,
- no water uses are ever interrupted and,
- conditions rarely depart from desirable quality.

Table 6. Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI), water quality variables and objectives or guidelines (Williamson 2001, Williamson 1988) used to calculate CWQI values (CCME 2000).

Variables	Units	Objective* Value	Objective* Use
Fecal Coliform MF	Bacteria/100mL	200	Recreation
Ph	Ph Units	6.5-9.0	Aquatic Life
Specific Conductivity	uS/cm	1000	Greenhouse Irrigation
Total Suspended Solids	mg/L	25 (mid range)	Aquatic Life
Dissolved Oxygen	mg/L	5 (mid range)	Aquatic Life
Total Arsenic	mg/L	0.025	Drinking Water, Health
Dissolved Aluminum	mg/L	0.1 for pH >6.5	Aquatic Life
Total or Extractable Cadmium	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total or Extractable Copper	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total or Extractable Lead	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total or Extractable Nickel	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total or Extractable Zinc	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total or Extractable Manganese	mg/L	0.05	Drinking Water, Aesthetic
Total or Extractable Iron	mg/L	0.3	Drinking Water, Aesthetic
Total Ammonia as N	mg/L	Calculation based pH	Aquatic Life
Soluble or Dissolved Nitrate-Nitrite	mg/L	10	Drinking Water, Health
Total Phosphorus	mg/L	0.05 in Rivers or 0.025 in Lakes	Nuisance Plant Growth
Dicamba	ug/L	0.006 where detectable	Irrigation
Bromoxynil	ug/L	0.33	Irrigation
Simazine	ug/L	0.5	Irrigation
2,4 D	ug/L	4	Aquatic Life
Lindane	ug/L	0.08	Aquatic Life
Atrazine	ug/L	1.8	Aquatic Life
MCPA*	ug/L	0.025 where detectable	Irrigation
Trifluralin	ug/L	0.2	Aquatic Life

* The next higer objective for MCPA is for Aquatic Life at 2.6 ug/L.

CCME CWQI (CCME 2001) Category ranges: 95-100 Excellent; 80-94 Good; 60-79 Fair; 45-59 Marginal; 0-44 Poor

$$\text{CCME CWQI} = 100-\left(\frac{\sqrt{F_1^2+F_2^2+F_3^2}}{1.732}\right)$$

Scope $F_1 = (\text{(Number of variables with an objective not met)/(Total number of variables)})\times 100$

Frequency $F_2 = (\text{(Number of samples with an objective not met)/(Total number of samples)})\times 100$

Amplitude $F_3 = (nse/(0.01nse + 0.01))$

Where *nse* is the normalized sum of test excursions:

$nse = (\text{Sum of excursions}_i)/(\text{Total number of tests})$

Where test values must not exceed the objective:

$\text{excursion}_i = (\text{Concentration}_i)/(\text{Objective}_j)$

Where test values must not fall below the objective:

$\text{excursion}_i = (\text{Objective}_j)/(\text{Concentration}_i)$

Where the objective is zero:

$\text{excursion}_i = \text{Concentration}_i$

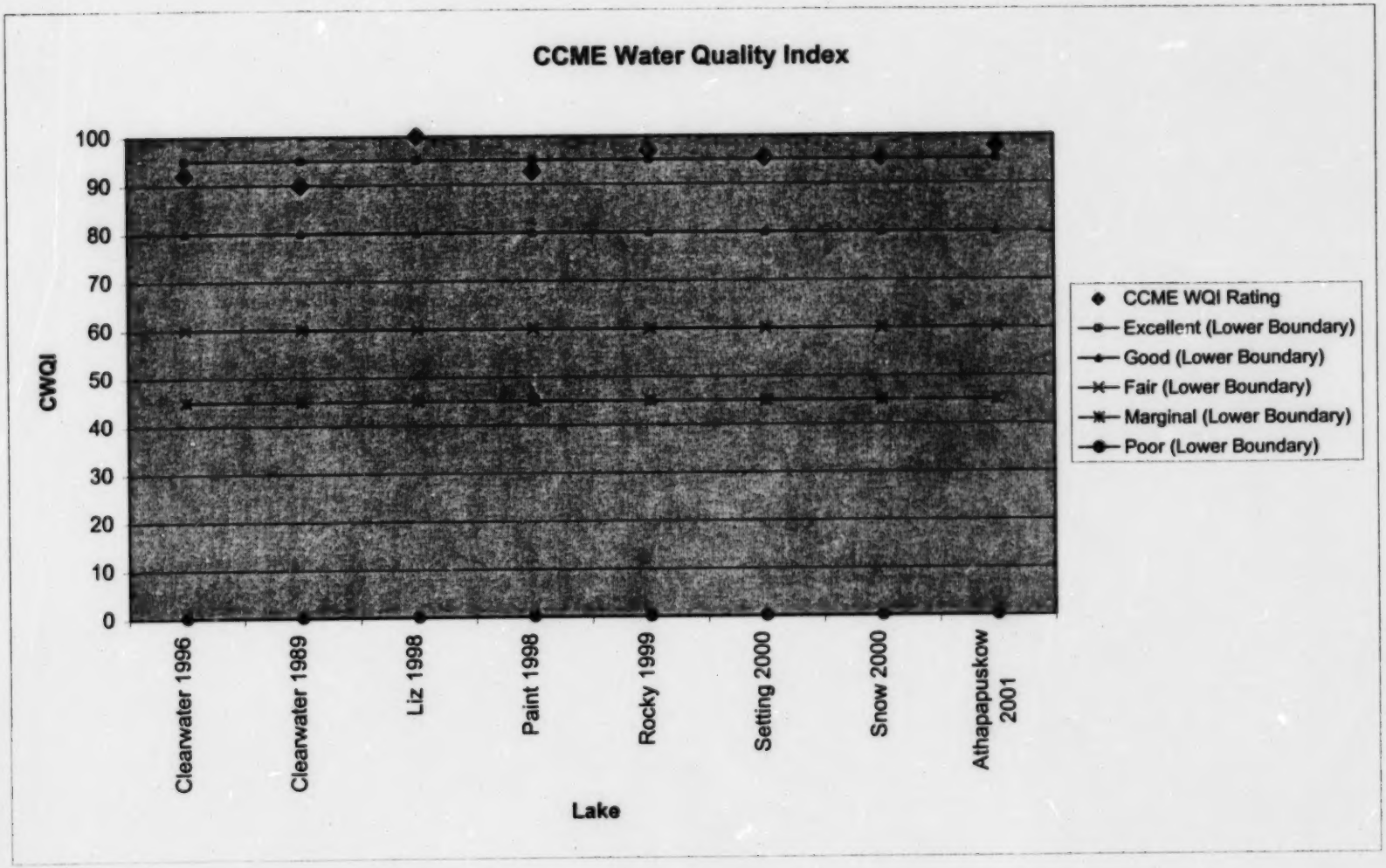

Figure 8. Comparison of CCME Water Quality Indices for seven northern lakes.

CONCLUSIONS

The Lake Athapapuskow study involved water quality sampling at three sites located near Cranberry Portage in the main basin of the lake and seven sites in the smaller northern basin (sometimes referred to as Little Athapapuskow Lake). Differences in water quality between the basins were likely due in part to the relative shallowness of the northern basin compared to the main body of the lake although some of these differences may be due to other factors. It can be concluded:

- Excellent bacteriological characteristics were monitored in Lake Athapapuskow but, as with all surface waters, lake water should always be boiled or disinfected before use for drinking.
- Trace metal concentrations were low and those used for the water quality index were all below their respective objectives.
- Pesticide concentrations were below detection limits.
- Dissolved oxygen concentrations were excellent.
- Ammonia and nitrate-nitrite nitrogen were low and well below water quality objectives.
- Dissolved phosphorus concentrations were fairly low and remained relatively stable throughout the summer of 2001.
- Total phosphorus concentrations were generally low and exceeded the water quality objective by a minor amount on only three occasions. Total phosphorus tended to be higher in the shallower areas of the Little Athapapuskow Lake area relative to the main body of Athapapuskow Lake.
- Chlorophyll *a* extracted from algae was generally very low but was significantly higher in the Little Athapapuskow Lake area relative to the main body of Athapapuskow Lake, and this was probably related to the slightly higher level of phosphorus in northern basin of the lake.
- The pH was not significantly different between basins.
- Specific conductivity was significantly higher in the Little Athapapuskow Lake area relative to the main body of Athapapuskow Lake. Although some of this might be due to inputs from Schist Creek there are two sites upstream of this location which showed similar average conductivities in 2001 and there may be some local runnoff contributions.
- Although there were differences in water quality between the main body of Athapapuskow Lake and the Little Athapapuskow Lake area, the overall water quality index (CCME WQI) rated the water quality in Lake Athapapuskow as "Excellent".

ACKNOWLEDGMENTS

We do greatly appreciate the volunteers who conducted most of the water sampling on Lake Athapapuskow. These included: Gerry Nomeland, George Barabonoff, Wayne Black, Hugh Meikle, and Richard Stahl of the Little Athapap Cottage Owners Association who sampled near Bakers Narrows, and Robert Huck, Larry Smerch, and Gary Wesner of the South Athapap Cottage Owners Association who sampled near Cranberry Portage. We are also grateful for the assistance of Steve Davis, and Darcy Chrisp of Manitoba Conservation.

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Appendix 1

Appendix 1. Physical, chemical, and biological variables in water samples collected from Lake Athapapuskow in the summer of 2001.

Site	Date	Temperature	Fecal Coliform Bacteria	E-Coli Bacteria	pH	Specific Conductivity	Turbidity	Secchi Disc	Nitrogen Nitrate-Nitrite	Nitrogen Total Ammonia	Total Phosphorus	Particulate Phosphorus	Dissolved Phosphorus	Chlorophyll a
	Units	Degrees C	Bacteria/100mL	Bacteria/100mL	pH units	uS/cm	NTU	m	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L
WQ2796	2001-06-26	13.0	< 10	< 10	8.24	353	0.80	4.0	< 0.02	0.03	0.006	< 0.002	0.005	0.8
WQ2797	2001-06-26	14.0	< 10	< 10	7.22	360	0.62	3.4	< 0.02	0.05	0.005	< 0.002	0.005	0.7
WQ0089	2001-06-26	15.0	< 10	< 10	7.28	352	0.75	4.0	< 0.02	0.03	0.005	< 0.002	0.005	0.7
WQ2798	2001-06-25	15.0	< 10	< 10	7.09	562	0.50	3.7	< 0.02	0.05	0.015	< 0.002	0.014	1.2
WQ2799	2001-06-25	16.0	< 10	< 10	7.04	539	2.20	3.4	< 0.02	0.05	0.033[b]	0.020	0.013	1.8
WQ2800	2001-06-25	15.0	< 10	< 10	7.13	545	0.64	3.2	< 0.02	0.05	0.023	0.010	0.013	1.3
WQ2801	2001-06-25	15.0	< 10	< 10	7.11	562	0.53	3.9	< 0.02	0.06	0.020	0.009	0.011	1.2
WQ0088	2001-06-25	16.0	< 10	< 10	7.11	486	0.52	3.1	< 0.02	0.05	0.019	0.006	0.013	1.3
WQ2802	2001-06-25	16.0	< 10	< 10	7.07	368	0.42	4.4	< 0.02	0.06	0.013	0.005	0.008	1.5
WQ2803	2001-06-25	17.0	< 10	< 10	7.06	343	0.37	4.3	< 0.02	0.06	0.012	0.002	0.010	1.2
WQ2796	2001-07-10	17.2	< 10	10	7.63	363	0.68	5.0	< 0.02	0.03	0.008	0.006	0.002	0.3
WQ2797	2001-07-10	17.8	< 10	< 10	7.86	347	0.66	5.0	< 0.02	0.06	0.008	0.005	0.003	0.3
WQ0089	2001-07-10	16.7	< 10	20	7.88	357	0.67	5.5	0.02	0.04	0.007	0.005	0.002	0.3
WQ2798	2001-07-11	17.0	< 10	< 10	8.28	965[a]	1.50	4.0	0.02	0.04	0.015	0.009	0.006	0.9
WQ2799	2001-07-11	20.0	< 10	< 10	8.01	582	0.54	4.0	0.02	0.02	0.019	0.009	0.010	1.1
WQ2800	2001-07-11	17.0	20	< 10	7.97	546	0.53	3.5	< 0.02	0.05	0.015	0.009	0.006	1.0
WQ2801	2001-07-11	18.0	< 10	< 10	8.02	601	0.62	4.1	< 0.02	0.03	0.014	0.009	0.005	1.0
WQ2802	2001-07-11	18.0	< 10	< 10	8.00	587	0.71	4.1	< 0.02	0.03	0.012	0.005	0.007	0.9
WQ2802	2001-07-11	18.0	< 10	< 10	7.97	533	0.40	5.0	< 0.02	0.02	0.013	0.008	0.005	1.0
WQ2803	2001-07-11	16.0	< 10	< 10	7.81	373	0.44	3.1	< 0.02	0.04	0.012	0.007	0.005	0.7
WQ2796	2001-07-24	20.0	< 10	< 10	8.00	343	1.40	5.5	0.03	0.10	0.011	0.006	0.005	0.6
WQ2797	2001-07-24	19.4	< 10	< 10	7.99	349	0.63	6.0	0.03	0.07	0.010	0.005	0.005	0.5
WQ0089	2001-07-24	19.0	< 10	< 10	7.98	348	0.39	6.5	0.03	0.05	0.012	0.008	0.004	0.4
WQ2798	2001-07-30	19.0	NA	NA	7.67	551	1.10	2.7	0.03	0.04	0.012	0.006	0.006	-
WQ2799	2001-07-30	19.0	< 10	< 10	7.77	540	0.45	3.2	0.06	0.04	0.018	0.003	0.015	2.5
WQ2800	2001-07-30	20.0	10	< 10	8.02	590	0.51	2.4	0.04	0.04	0.011	0.004	0.007	2.0
WQ2801	2001-07-30	20.0	< 10	< 10	8.00	574	0.76	2.3	0.05	0.06	0.014	0.009	0.005	2.7
WQ0088	2001-07-30	19.0	< 10	< 10	7.97	528	0.51	2.9	0.09	0.04	0.012	0.006	0.006	1.9
WQ2802	2001-07-30	18.0	< 10	< 10	7.88	374	0.37	3.6	0.09	0.04	0.012	0.006	0.006	1.2
WQ2803	2001-07-30	20.0	10	< 10	7.88	342	0.50	3.1	< 0.02	0.10	0.012	0.004	0.008	3.5
WQ2796	2001-08-06	21.7	< 10	< 10	7.60	343	0.33	5.5	0.04	0.02	0.007	0.003	0.004	0.3
WQ2797	2001-08-06	21.7	< 10	< 10	7.87	344	0.33	6.0	0.06	0.02	0.006	0.002	0.004	0.2
WQ0089	2001-08-06	21.1	< 10	< 10	7.92	345	0.41	6.0	0.04	0.03	0.006	0.002	0.004	0.3
WQ2798	2001-08-06	21.0	< 10	10	7.99	541	1.50	3.5	< 0.02	0.03	0.018	0.009	0.009	1.9
WQ2799	2001-08-06	23.0	< 10	10	7.95	537	0.61	2.6	< 0.02	0.02	0.017	0.008	0.009	2.9
WQ2800	2001-08-06	21.0	< 10	30	8.10	583	0.75	2.9	< 0.02	0.04	0.015	0.010	0.005	2.8
WQ2801	2001-08-06	23.0	< 10	< 10	8.17	561	0.55	2.8	< 0.02	0.03	0.012	0.007	0.005	1.9
WQ0088	2001-08-06	22.0	< 10	< 10	8.08	497	0.51	3.0	< 0.02	0.04	0.015	0.009	0.006	1.7
WQ2802	2001-08-06	20.0	NA	NA	8.02	351	0.42	4.0	< 0.02	0.02	0.014	0.007	0.007	2.6
WQ2803	2001-08-06	22.0	< 10	< 10	7.95	331	0.63	3.0	< 0.02	0.02	0.017	0.012	0.005	2.2
WQ2796	2001-08-19	19.4	< 10	< 10	7.89	329	0.69	5.0	0.02	0.03	0.007	0.003	0.004	0.4
WQ2797	2001-08-19	19.0	< 10	< 10	7.95	322	0.66	5.5	0.02	0.02	0.007	0.002	0.005	0.5
WQ0089	2001-08-19	19.0	< 10	< 10	7.97	316	0.51	6.5	0.02	0.04	0.006	< 0.002	0.006	0.4
WQ2798	2001-08-20	19.0	< 10	< 10	7.84	546	3.40	3.3	0.02	0.05	0.018	0.009	0.009	2.5
WQ2799	2001-08-20	20.0	< 10	< 10	7.86	515	0.59	3.2	0.03	0.04	0.016	0.008	0.010	2.1
WQ2800	2001-08-20	19.0	< 10	< 10	7.99	553	0.72	3.5	0.05	0.04	0.015	0.007	0.008	2.4
WQ2801	2001-08-20	19.0	< 10	< 10	7.98	536	0.76	2.8	0.05	0.04	0.018	0.010	0.008	2.2
WQ0088	2001-08-20	19.0	< 10	< 10	7.98	523	0.63	3.0	0.06	0.03	0.017	0.010	0.007	2.2
WQ2802	2001-08-20	19.0	< 10	< 10	7.95	343	0.41	4.1	0.06	0.03	0.017	0.008	0.009	2.2
WQ2803	2001-08-20	19.0	< 10	< 10	7.98	335	0.48	4.4	0.06	0.04	0.016	0.008	0.008	1.8

Appendix 1. (continued).

Site	Date	Temperature	Fecal Coliform Bacteria	E-Coli Bacteria	pH	Specific Conductivity	Turbidity	Secchi Disc	Nitrogen Nitrate-Nitrite	Nitrogen Total Ammonia	Total Phosphorus	Particulate Phosphorus	Dissolved Phosphorus	Chlorophyll a
	Units	Degrees C	Bacteria/100mL	Bacteria/100mL	pH units	uS/cm	NTU	m	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L
WQ2796	2001-09-03	17.2	< 10	< 10	8.08	310	0.60	5.0	< 0.02	0.03	0.009	0.002	0.007	1.5
WQ2797	2001-09-03	17.2	< 10	< 10	8.10	315	0.56	5.5	< 0.02	0.03	0.008	< 0.002	0.008	1.7
WQ0089	2001-09-03	17.2	< 10	< 10	8.10	312	0.59	6.5	< 0.02	0.03	0.009	0.004	0.005	1.3
WQ2798	2001-09-05	17.0	NA	NA	7.64	549	0.70	3.3	< 0.02	0.10	0.014	0.009	0.005	0.8
WQ2799	2001-09-05	17.0	NA	NA	7.55	521	0.42	2.8	< 0.02	0.07	0.021	0.010	0.011	0.7
WQ2800	2001-09-05	16.0	NA	NA	7.79	576	0.51	3.1	< 0.02	0.05	0.015	0.009	0.006	0.6
WQ2801	2001-09-05	17.0	NA	NA	7.81	515	0.89	2.7	< 0.02	0.06	0.021	0.014	0.007	1.4
WQ0088	2001-09-05	17.0	NA	NA	7.83	487	0.47	3.3	< 0.02	0.09	0.014	0.008	0.006	0.8
WQ2802	2001-09-05	17.0	NA	NA	7.78	336	0.38	3.6	< 0.02	0.06	0.017	0.011	0.006	0.9
WQ2803	2001-09-05	13.0	NA	NA	7.72	327	0.42	3.4	< 0.02	< 0.02	0.018	0.012	0.006	1.0
WQ2796	2001-09-17	15.0	< 10	< 10	7.10	340	0.48	5.0	0.10	0.12	0.011	0.006	0.005	0.7
WQ2797	2001-09-17	15.0	< 10	< 10	7.56	337	0.53	5.5	0.08	0.08	0.009	0.002	0.007	0.8
WQ0089	2001-09-17	14.4	< 10	< 10	7.71	342	0.45	6.2	0.14	0.08	0.010	0.005	0.005	0.8
WQ2798	2001-09-16	16.0	< 10	< 10	7.01	555	0.75	3.7	< 0.02	0.04	0.017	0.009	0.008	2.0
WQ2799	2001-09-16	15.0	< 10	< 10	7.38	522	0.45	2.7	0.20	0.06	0.023	0.012	0.011	2.0
WQ2800	2001-09-16	17.0	< 10	< 10	7.63	571	0.60	3.2	0.15	0.03	0.022	0.013	0.009	2.0
WQ2801	2001-09-16	17.0	< 10	< 10	7.71	538	0.52	3.5	0.12	0.03	0.033[b]	0.026	0.007	1.7
WQ0088	2001-09-16	16.0	< 10	< 10	7.65	346	0.55	3.0	0.05	0.02	0.026[b]	0.015	0.011	2.7
WQ2802	2001-09-16	15.0	< 10	< 10	7.64	341	0.55	3.8	0.09	0.04	0.023	0.013	0.010	2.8
WQ2803	2001-09-16	13.0	< 10	< 10	7.69	335	0.54	3.4	0.06	0.05	0.020	0.012	0.008	3.2
Average		**17.9**	**10**	**10**	**7.76**	**442**	**0.67**	**4.8**	**0.04**	**0.04**	**0.014**	**0.007**	**0.007**	**1.4**
Standard Deviation		**2.4**	**1**	**3**	**0.33**	**105**	**0.45**	**1.1**	**0.04**	**0.02**	**0.006**	**0.004**	**0.003**	**0.8**
Count		**70**	**61**	**61**	**70**	**69**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**69**

a. Specific Conductivity for a water sample collected on July 11, 2001 at site WQ2798 was an outlier which appeared to be in error and has therefore been left out of further calculations.

b. Total phosphorus which exceeded a guideline of 0.025 mg/L for lakes.

Appendix 2

Appendix 2. Historical water quality data from two sites in Lake Athapapuskow, 1976 through 1984.

Site	Date	Temperature °C	Bacteria Total Coliform MPN Bacteria/100mL	Bacteria Fecal Coliform MPN Bacteria/100mL	pH Laboratory pH units	pH Field pH units	Specific Conductivity, Lab. uS/cm	Specific Conductivity, Field uS/cm	Total Dissolved Solids mg/L	Total Suspended Solids mg/L
WQ0089	1976-01-27	0.0	0	0	7.90	—	348	—	216	< 5
WQ0089	1976-02-16	0.0	0	0	7.90	—	354	—	226	< 5
WQ0089	1976-03-16	0.0	0	0	7.80	—	357	—	222	< 5
WQ0089	1976-06-29	—	0	0	7.95	—	312	—	197	7
WQ0089	1976-07-26	—	0	0	8.20	—	314	—	194	< 5
WQ0089	1976-08-17	—	9	0	8.25	—	314	—	198	< 5
WQ0089	1976-09-22	—	0	—	8.20	—	311	—	200	< 5
WQ0089	1976-10-13	—	0	0	8.00	—	322	—	196	8
WQ0089	1977-03-01	0.0	0	0	7.90	—	345	—	302	< 5
WQ0089	1977-05-31	—	0	0	8.10	—	319	—	210	< 5
WQ0089	1977-07-12	18.0	0	0	8.00	—	315	—	208	< 5
WQ0089	1977-08-17	15.0	4	0	8.20	—	322	—	214	< 5
WQ0089	1977-09-20	12.0	4	0	7.95	—	323	—	202	< 5
WQ0089	1977-10-17	9.0	0	0	8.05	—	326	—	187	5
WQ0089	1978-02-08	0.0	9	4	7.95	—	357	—	—	—
WQ0089	1978-03-08	0.0	0	0	7.90	7.35	361	320	—	—
WQ0089	1978-06-06	10.0	0	0	8.05	7.75	311	320	—	—
WQ0089	1978-07-11	19.0	0	0	8.15	8.25	322	320	—	—
WQ0089	1978-08-16	18.0	4	0	8.05	6.85	329	290	—	< 5
WQ0089	1978-09-12	11.0	4	4	8.10	7.55	329	325	—	9
WQ0089	1978-10-17	6.0	0	0	8.00	—	329	315	—	5
WQ0088	1976-01-27	0.0	0	0	7.60	—	525	—	358	< 5
WQ0088	1976-02-16	0.0	0	0	7.70	—	361	—	238	< 5
WQ0088	1976-03-16	0.0	0	0	7.20	—	362	—	242	< 5
WQ0088	1976-06-29	—	0	0	8.00	—	492	—	314	6
WQ0088	1976-07-26	—	7	0	8.15	—	302	—	206	< 5
WQ0088	1976-08-17	—	0	0	8.15	—	509	—	352	< 5
WQ0088	1976-09-22	—	0	—	7.85	—	497	—	316	< 5
WQ0088	1976-10-13	—	4	0	7.85	—	475	—	303	7
WQ0088	1977-03-01	0.0	0	0	7.60	—	454	—	302	< 5
WQ0088	1977-05-31	—	0	0	8.00	—	477	—	326	6
WQ0088	1977-07-12	19.5	0	0	8.10	—	491	—	340	< 5
WQ0088	1977-08-17	15.0	9	0	7.80	—	463	—	315	5
WQ0088	1977-09-20	12.0	9	0	7.85	—	475	—	312	< 5
WQ0088	1977-10-17	10.0	0	0	7.60	—	504	—	319	7
WQ0088	1978-02-08	0.0	0	0	7.45	—	419	—	—	—
WQ0088	1978-03-08	0.0	0	0	7.50	7.40	350	340	—	—
WQ0088	1978-06-06	11.0	4	0	7.85	8.25	486	600	—	—
WQ0088	1978-07-11	20.0	4	0	8.15	7.80	499	475	—	—
WQ0088	1978-08-16	20.0	9	0	8.00	7.25	461	400	—	< 5
WQ0088	1978-09-12	13.5	4	0	7.85	7.65	475	465	—	12
WQ0088	1978-10-17	7.5	9	0	7.70	—	492	440	—	6
WQ0088	1979-01-10	0.0	4	0	7.80	—	1180[a]	—	—	< 5
WQ0088	1979-02-06	0.0	0	0	7.90	—	361	—	—	7
WQ0088	1979-03-07	0.0	0	0	7.45	—	370	—	—	< 5
WQ0088	1979-06-14	11.5	9	0	7.80	—	464	440	—	< 5
WQ0088	1979-07-10	22.0	4	0	8.15	—	490	480	—	< 5
WQ0088	1979-08-15	16.0	4	4	8.15	—	462	536	—	< 5
WQ0088	1979-10-16	7.0	15	0	7.80	—	466	465	—	< 5
WQ0088	1980-01-09	0.0	0	0	7.82	—	389	—	—	< 5
WQ0088	1980-02-13	0.0	0	0	7.50	—	367	—	—	< 5
WQ0088	1980-03-11	0.0	4	0	7.60	—	383	—	—	7
WQ0088	1980-06-11	15.0	4	4	8.00	—	479	440	—	< 5
WQ0088	1980-07-09	19.0	9	9	8.00	7.90	466	400	—	16
WQ0088	1980-08-12	19.0	23	23	8.20	8.20	469	425	—	< 5
WQ0088	1980-09-11	15.5	0	0	7.60	—	502	850	—	< 5
WQ0088	1981-01-21	0.0	4	0	7.60	—	380	—	—	< 5
WQ0088	1981-02-17	0.0	0	0	7.60	—	395	—	—	< 5
WQ0088	1981-03-17	0.0	0	0	7.65	—	344	—	—	< 5
WQ0088	1981-06-03	13.5	0	0	7.90	7.89	424	434	—	< 5
WQ0088	1981-07-29	19.0	9	4	8.10	7.94	419	426	—	< 5
WQ0088	1981-10-06	10.0	0	0	7.83	7.80	496	482	—	< 5
WQ0088	1982-01-12	0.0	0	0	7.85	—	397	—	—	< 5
WQ0088	1982-02-09	0.0	0	0	7.70	—	426	—	—	< 5
WQ0088	1982-03-10	0.0	0	0	7.50	—	416	—	—	< 5
WQ0088	1982-06-08	9.5	0	0	7.85	—	429	477	—	< 5
WQ0088	1982-07-08	—	9	4	8.10	—	446	—	—	< 5
WQ0088	1982-08-16	—	0	0	8.15	—	347	—	—	< 5
WQ0088	1983-07-05	16.5	0	0	8.10	—	337	351	—	< 5
WQ0088	1983-08-23	17.0	4	0	8.00	—	371	474	—	< 5
WQ0088	1983-09-21	11.5	0	0	7.30	—	505	473	—	< 5
WQ0088	1984-01-11	0.0	0	0	7.80	—	397	—	—	8
WQ0088	1984-02-07	0.0	0	0	7.85	—	383	—	—	< 5
WQ0088	1984-03-06	0.0	0	0	7.65	—	349	—	—	< 5

a. Outlier value for specific conductivity of 1180 uS/cm from site WQ0088 in 1979 may be in error and is excluded from calculations.

Appendix 2. (continued).

Site	Date	Turbidity Laboratory NTU	True Color Colour Units	Total Alkalinity $CaCO_3$ mg/L	Bicarbonate Alkalinity HCO_3 mg/L	Carbonate Alkalinity CO_3 mg/L	Hydroxide Alkalinity OH mg/L	Dissolved Oxygen mg/L	Total Organic Carbon C mg/L	Total Inorganic Carbon C mg/L	Nitrate & Nitrite Nitrogen N mg/L
WQ0089	1976-01-27	0.95	< 5	80	98.0	0	0	—	8.0	18.0	0.05
WQ0089	1976-02-16	0.20	< 5	82	100.0	0	0	—	7.0	18.5	0.06
WQ0089	1976-03-16	0.45	8	76	93.0	0	0	—	8.0	17.5	0.04
WQ0089	1976-06-29	0.70	< 5	64	78.1	0	0	—	8.0	12.5	0.01
WQ0089	1976-07-26	0.95	< 5	60	73.2	0	0	—	12.5	17.5	0.14
WQ0089	1976-08-17	0.50	5	62	75.6	0	0	—	12.0	17.0	0.02
WQ0089	1976-09-22	10	< 5	62	75.6	0	0	—	10.0	14.5	0.05
WQ0089	1976-10-13	1.00	5	63	76.8	0	0	—	7.5	12.5	0.01
WQ0089	1977-03-01	0.55	< 5	70	85.4	0	0	—	7.5	16.5	0.03
WQ0089	1977-05-31	0.85	< 5	62	75.6	0	0	10.9	10.0	15.0	0.25
WQ0089	1977-07-12	0.44	< 5	60	73.2	0	0	9.6	7.5	14.0	0.15
WQ0089	1977-08-17	1.30	< 5	64	78.1	0	0	9.8	9.5	3.5	< 0.01
WQ0089	1977-09-20	1.10	< 5	62	75.6	0	0	9.8	7.0	15.0	0.9
WQ0089	1977-10-17	0.95	5	62	75.6	0	0	9.9	8.0	15.5	0.02
WQ0089	1978-02-08	—	—	—	—	—	—	13.6	—	—	0.08
WQ0089	1978-03-08	—	—	—	—	—	—	14.1	—	—	0.05
WQ0089	1978-06-06	—	—	—	—	—	—	10.8	—	—	1.1
WQ0089	1978-07-11	—	—	—	—	—	—	9.0	—	—	0.13
WQ0089	1978-08-16	—	—	—	—	—	—	9.4	—	—	< 0.01
WQ0089	1978-09-12	—	—	—	—	—	—	10.2	—	—	0.06
WQ0089	1978-10-17	—	—	—	—	—	—	11.3	—	—	< 0.01
WQ0088	1976-01-27	1.00	5	76	93.0	0	0	—	9.0	13.0	0.17
WQ0088	1976-02-16	0.60	8	70	85.0	0	0	—	16.5	15.0	0.24
WQ0088	1976-03-16	0.45	10	82	100.0	0	0	—	12.0	15.0	0.06
WQ0088	1976-06-29	0.75	< 5	54	65.9	0	0	—	8.5	9.5	0.01
WQ0088	1976-07-26	1.00	5	52	63.4	0	0	—	16.5	17.5	< 0.01
WQ0088	1976-08-17	1.00	< 5	49	60.0	0	0	—	12.5	11.5	0.01
WQ0088	1976-09-22	10	5	52	63.4	0	0	—	11.5	10.5	0.01
WQ0088	1976-10-13	1.50	10	53	64.6	0	0	—	8.5	10.5	0.03
WQ0088	1977-03-01	0.45	< 5	66	80.0	0	0	—	12.0	15.0	0.07
WQ0088	1977-05-31	0.75	< 5	50	61.0	0	0	10.8	10.5	11.0	0.12
WQ0088	1977-07-12	0.96	< 5	48	58.6	0	0	2.2	10.0	11.0	0.03
WQ0088	1977-08-17	1.20	< 5	48	58.6	0	0	9.0	10.5	11.0	< 0.01
WQ0088	1977-09-20	1.60	5	50	61.0	0	0	9.9	10.5	11.5	0.22
WQ0088	1977-10-17	1.60	5	50	61.0	0	0	9.3	55.5	11.5	0.06
WQ0088	1978-02-08	—	—	—	—	—	—	11.9	—	—	0.14
WQ0088	1978-03-08	—	—	—	—	—	—	12.5	—	—	0.16
WQ0088	1978-06-06	—	—	—	—	—	—	11.2	—	—	0.07
WQ0088	1978-07-11	—	—	—	—	—	—	9.7	—	—	0.06
WQ0088	1978-08-16	—	—	—	—	—	—	—	—	—	0.01
WQ0088	1978-09-12	—	—	—	—	—	—	9.5	—	—	0.04
WQ0088	1978-10-17	—	—	—	—	—	—	10.3	—	—	0.01
WQ0088	1979-01-10	—	—	—	—	—	—	12.6	—	—	0.03
WQ0088	1979-02-06	—	—	—	—	—	—	11.6	—	—	0.02
WQ0088	1979-03-07	—	—	—	—	—	—	11.4	—	—	0.07
WQ0088	1979-06-14	—	—	—	—	—	—	11.2	—	—	< 0.01
WQ0088	1979-07-10	—	—	—	—	—	—	9.5	—	—	< 0.01
WQ0088	1979-08-15	—	—	—	—	—	—	9.2	—	—	< 0.01
WQ0088	1979-10-16	—	—	—	—	—	—	10.1	—	—	0.03
WQ0088	1980-01-09	—	—	—	—	—	—	13.0	—	—	0.03
WQ0088	1980-02-13	—	—	—	—	—	—	12.4	—	—	0.03
WQ0088	1980-03-11	—	—	—	—	—	—	12.4	—	—	0.05
WQ0088	1980-06-11	—	—	52	63.4	0	0	10.3	—	—	0.01
WQ0088	1980-07-09	—	—	76	93.0	0	0	9.5	—	—	0.01
WQ0088	1980-08-12	—	—	52	63.0	0	0	8.9	—	—	< 0.01
WQ0088	1980-09-11	—	—	52	63.0	0	0	8.8	—	—	< 0.01
WQ0088	1981-01-21	—	—	59	71.0	0	0	11.9	13.5	14.5	0.85
WQ0088	1981-02-17	—	—	64	78.0	0	0	12.2	14.0	15.0	0.03
WQ0088	1981-03-17	—	—	66	81.0	0	0	12.3	14.0	16.5	0.06
WQ0088	1981-06-03	1.00	—	58	70.0	0	0	11.5	11.0	13.0	< 0.01
WQ0088	1981-07-29	0.75	—	54.2	66.2	0	0	8.8	9.5	12.5	0.01
WQ0088	1981-10-06	1.00	—	55.6	67.8	0	0	9.8	8.5	12.0	< 0.01
WQ0088	1982-01-12	0.45	—	61	74.4	0	0	13.0	11.0	13.0	0.02
WQ0088	1982-02-09	0.50	—	66	80.5	0	0	13.2	10.5	14.0	0.02
WQ0088	1982-03-10	0.50	—	64	78.1	0	0	9.2	13.0	14.5	0.03
WQ0088	1982-06-08	0.55	—	56	68.3	0	0	10.4	8.5	11.5	< 0.01
WQ0088	1982-07-08	0.95	—	55	67.1	0	0	8.5	10.0	11.0	< 0.01
WQ0088	1982-08-16	1.00	—	56	68.3	0	0	8.9	9.5	10.5	< 0.01
WQ0088	1983-07-05	1.00	—	58	70.8	0	0	9.8	13.0	13.0	< 0.01
WQ0088	1983-08-23	0.70	—	58	70.8	0	0	9.5	11.5	11.0	< 0.01
WQ0088	1983-09-21	0.80	—	56	68.3	0	0	9.2	7.0	13.0	0.03
WQ0088	1984-01-11	0.80	—	66	80.5	0	0	14.9	11.5	14.5	0.02
WQ0088	1984-02-07	1.00	—	64	78.1	0	0	13.3	9.0	16.5	0.02
WQ0088	1984-03-06	0.75	—	68	83.0	0	0	12.2	12.0	12.5	0.02

Appendix 2. (continued).

Site	Date	Ammonia Nitrogen N mg/L	Total Kjeldahl Nitrogen N mg/L	Total Phosphorus mg/L as P	Ortho Phosphorus mg/L as P	Fluoride F mg/L	Chloride Cl mg/L	Sulphate SO_4 mg/L	Total Hardness $CaCO_3$ mg/L	Arsenic As Extractable mg/L	Cadmium Cd Extractable mg/L	Calcium Ca Extractable mg/L
WQ0089	1976-01-27	< 0.02	0.40	< 0.020	< 0.020	0.12	31.0	55	137	< 0.040	< 0.005	40.0
WQ0089	1976-02-16	0.14	0.35	< 0.020	< 0.020	0.12	34.0	—	147	< 0.040	< 0.005	42.5
WQ0089	1976-03-16	0.04	0.30	< 0.020	< 0.020	0.14	33.0	50	152	< 0.040	< 0.005	47.5
WQ0089	1976-06-29	0.20	0.40	< 0.020	< 0.020	0.13	28.0	40	125	< 0.040	< 0.005	35.0
WQ0089	1976-07-26	0.07	0.80	< 0.020	< 0.020	0.09	29.0	50	121	< 0.040	< 0.005	35.0
WQ0089	1976-08-17	0.05	0.20	< 0.020	< 0.020	0.09	29.0	45	121	< 0.040	< 0.005	35.0
WQ0089	1976-09-22	< 0.02	0.30	< 0.020	< 0.020	0.11	31.0	45	129	< 0.040	< 0.005	35.0
WQ0089	1976-10-13	< 0.02	0.30	< 0.020	< 0.020	0.09	30.0	45	121	< 0.040	< 0.005	35.0
WQ0089	1977-03-01	—	—	< 0.020	—	—	35.0	50	137	< 0.040	< 0.005	40.0
WQ0089	1977-05-31	—	—	< 0.020	—	—	32.0	90	131	< 0.005	< 0.005	37.5
WQ0089	1977-07-12	—	—	0.009	0.005	—	34.0	45	141	< 0.005	< 0.005	40.0
WQ0089	1977-08-17	—	—	0.015	—	—	31.0	45	139	0.010	< 0.005	42.5
WQ0089	1977-09-20	—	—	0.020	—	—	30.5	44	130	< 0.005	< 0.005	38.8
WQ0089	1977-10-17	—	—	0.008	—	—	31.5	39	129	< 0.005	< 0.005	38.0
WQ0089	1978-02-08	—	0.30	< 0.020	—	—	—	—	—	< 0.005	< 0.005	—
WQ0089	1978-03-08	—	0.25	< 0.020	—	—	—	—	—	< 0.005	< 0.005	—
WQ0089	1978-06-06	—	0.90	0.320	—	—	—	—	—	< 0.001	0.005	—
WQ0089	1978-07-11	—	0.20	0.007	—	—	—	—	—	< 0.001	< 0.005	—
WQ0089	1978-08-16	—	0.20	< 0.020	—	—	—	—	—	0.002	< 0.005	—
WQ0089	1978-09-12	—	0.40	< 0.020	—	—	—	—	—	0.001	< 0.005	—
WQ0089	1978-10-17	—	0.45	0.007	—	—	—	—	—	0.001	< 0.005	—
WQ0088	1976-01-27	0.04	0.50	0.020	< 0.020	0.11	71.0	105	216	< 0.040	0.02	70.0
WQ0088	1976-02-16	0.07	0.60	0.020	< 0.020	0.14	38.0	—	148	< 0.040	< 0.005	45.0
WQ0088	1976-03-16	0.02	0.40	< 0.020	< 0.020	0.14	36.0	50	148	< 0.040	< 0.005	47.5
WQ0088	1976-06-29	0.06	0.40	< 0.020	< 0.020	0.13	64.0	85	181	< 0.040	< 0.005	57.5
WQ0088	1976-07-26	0.02	0.40	< 0.020	< 0.020	0.09	30.0	50	113	< 0.040	< 0.005	35.0
WQ0088	1976-08-17	0.05	0.30	< 0.020	< 0.020	0.11	68.0	95	179	< 0.040	< 0.005	55.0
WQ0088	1976-09-22	0.34	0.80	0.040	< 0.020	0.12	67.0	90	191	< 0.040	< 0.005	60.0
WQ0088	1976-10-13	< 0.02	0.40	0.020	< 0.020	0.11	62.0	85	171	< 0.040	< 0.005	55.0
WQ0088	1977-03-01	—	—	< 0.020	—	—	55.0	75	175	< 0.040	< 0.005	55.0
WQ0088	1977-05-31	—	—	0.020	—	—	65.0	90	187	< 0.005	< 0.005	60.0
WQ0088	1977-07-12	—	—	0.027	0.003	—	65.0	85	216	< 0.005	< 0.005	70.0
WQ0088	1977-08-17	—	—	0.020	—	—	59.0	80	189	< 0.005	< 0.005	62.5
WQ0088	1977-09-20	—	—	0.018	—	—	59.0	79	174	< 0.005	< 0.005	56.3
WQ0088	1977-10-17	—	—	—	—	—	65.5	82	208	< 0.005	< 0.005	68.0
WQ0088	1978-02-08	—	0.30	< 0.020	—	—	—	—	—	< 0.005	< 0.005	—
WQ0088	1978-03-08	—	0.30	< 0.020	—	—	—	—	—	< 0.005	< 0.005	—
WQ0088	1978-06-06	—	0.20	0.040	—	—	—	—	—	< 0.001	0.005	—
WQ0088	1978-07-11	—	0.30	0.009	—	—	—	—	—	0.001	< 0.005	—
WQ0088	1978-08-16	—	0.30	< 0.020	—	—	—	—	—	0.002	< 0.005	—
WQ0088	1978-09-12	—	0.50	0.040	—	—	—	—	—	0.002	< 0.005	—
WQ0088	1978-10-17	—	0.55	0.012	—	—	—	—	—	0.002	< 0.005	—
WQ0088	1979-01-10	—	0.50	0.015	—	—	—	—	—	0.003	< 0.005	—
WQ0088	1979-02-06	—	0.50	0.018	—	—	—	—	—	0.002	< 0.005	—
WQ0088	1979-03-07	—	0.35	0.016	—	—	—	—	—	0.003	< 0.005	—
WQ0088	1979-06-14	—	0.30	< 0.020	—	—	—	—	—	0.002	0.005	—
WQ0088	1979-07-10	—	0.40	0.013	—	—	—	—	—	0.002	< 0.005	—
WQ0088	1979-08-15	—	0.30	0.160	—	—	—	—	—	0.002	< 0.005	—
WQ0088	1979-10-16	—	0.40	0.040	—	—	—	—	—	0.002	0.005	—
WQ0088	1980-01-08	—	0.40	0.040	—	—	—	—	—	0.002	< 0.005	—
WQ0088	1980-02-13	—	0.60	0.041	—	—	—	—	—	0.003	< 0.005	—
WQ0088	1980-03-11	—	0.50	0.020	—	—	—	—	—	0.002	< 0.005	—
WQ0088	1980-06-11	—	0.30	0.019	—	—	—	—	—	0.001	< 0.005	60.0
WQ0088	1980-07-09	—	0.40	0.050	—	—	—	—	—	0.002	< 0.005	55.0
WQ0088	1980-08-12	—	0.40	0.050	—	—	—	—	—	0.001	< 0.005	58.0
WQ0088	1980-09-11	—	0.40	0.013	—	—	—	—	—	0.002	< 0.005	65.0
WQ0088	1981-01-21	—	0.30	—	—	—	—	—	—	0.003	0.005	49.0
WQ0088	1981-02-17	—	0.40	0.010	—	—	—	—	—	0.001	< 0.005	49.0
WQ0088	1981-03-17	—	0.30	0.050	—	—	—	—	—	0.003	< 0.005	48.0
WQ0088	1981-06-03	—	0.40	0.020	—	—	—	—	—	0.001	< 0.005	60.0
WQ0088	1981-07-29	—	0.40	0.030	—	—	—	—	—	0.002	< 0.005	55.0
WQ0088	1981-10-06	—	0.40	0.020	—	—	—	—	—	0.003	< 0.005	63.0
WQ0088	1982-01-12	—	0.40	0.020	—	—	—	—	—	0.004	< 0.005	50.0
WQ0088	1982-02-09	—	0.40	0.020	—	—	—	—	—	< 0.001	< 0.005	63.5
WQ0088	1982-03-10	—	0.30	0.020	—	—	—	—	—	0.004	< 0.005	58.7
WQ0088	1982-06-08	—	0.30	0.017	—	—	—	—	197	—	—	64.0
WQ0088	1982-07-06	—	0.40	0.013	—	—	—	—	—	0.003	< 0.005	58.5
WQ0088	1982-08-16	—	0.40	0.010	—	—	—	—	—	0.002	< 0.005	35.0
WQ0088	1983-07-05	—	0.70	0.020	—	—	—	—	—	0.002	< 0.0010	39.2
WQ0088	1983-08-23	—	0.50	0.015	—	—	—	—	—	0.001	< 0.0010	58.5
WQ0088	1983-09-21	—	0.40	0.050	—	—	—	—	—	< 0.001	< 0.0010	67.9
WQ0088	1984-01-11	—	0.50	0.010	—	—	—	—	—	0.001	< 0.0010	51.7
WQ0088	1984-02-07	—	0.40	0.020	—	—	—	—	—	0.004	< 0.0010	50.6
WQ0088	1984-03-06	—	0.40	0.012	—	—	—	—	—	< 0.001	< 0.0010	47.7

Appendix 2. (continued).

Site	Date	Hexavalent Chromium Cr+6 Extratable mg/L	Copper Cu Extratable mg/L	Iron Fe Extratable mg/L	Lead Pb Extratable mg/L	Magnesium Mg Extratable mg/L	Manganese Mn Extratable mg/L	Nickel Ni Extratable mg/L	Potassium K Extratable mg/L	Sodium Na Extratable mg/L	Zinc Zn Extratable mg/L
WQ0089	1976-01-27	—	< 0.005	< 0.02	< 0.010	9.00	< 0.02	0.010	2.0	10	< 0.005
WQ0089	1976-02-16	—	< 0.005	< 0.02	0.010	10.0	< 0.02	< 0.010	2.0	< 10	< 0.005
WQ0089	1976-03-16	—	< 0.005	0.02	0.010	8.00	< 0.02	< 0.010	2.0	10	—
WQ0089	1976-06-29	—	0.005	0.08	< 0.010	9.00	< 0.02	0.170	2.0	10	< 0.005
WQ0089	1976-07-26	—	0.019	0.06	< 0.010	8.00	< 0.02	< 0.010	2.1	< 10	< 0.005
WQ0089	1976-08-17	—	< 0.005	0.12	< 0.010	8.00	< 0.02	0.020	2.0	< 10	0.050
WQ0089	1976-09-22	—	< 0.005	0.02	0.020	10.0	< 0.02	< 0.010	2.0	10	0.025
WQ0089	1976-10-13	—	< 0.005	< 0.02	0.010	8.00	< 0.02	< 0.010	2.1	10	< 0.025
WQ0089	1977-03-01	—	0.010	0.05	< 0.010	9.00	< 0.02	0.020	2.6	10	< 0.005
WQ0089	1977-05-31	—	0.005	< 0.02	< 0.010	9.00	< 0.02	0.018	2.4	10	0.010
WQ0089	1977-07-12	—	0.005	< 0.02	< 0.005	10.0	< 0.02	0.005	2.0	10	0.020
WQ0089	1977-08-17	—	< 0.005	< 0.02	< 0.005	8.00	< 0.02	0.005	2.1	10	0.020
WQ0089	1977-09-20	—	< 0.005	0.02	0.010	8.00	< 0.02	0.022	2.1	10	0.010
WQ0089	1977-10-17	—	< 0.005	0.04	0.010	9.00	< 0.02	0.020	2.4	10	0.020
WQ0089	1978-02-08	—	< 0.005	—	0.005	—	—	0.010	—	—	0.020
WQ0089	1978-03-08	< 0.02	0.015	—	0.005	—	—	0.005	—	—	0.020
WQ0089	1978-06-06	< 0.02	0.005	—	0.015	—	—	0.030	—	—	0.010
WQ0089	1978-07-11	< 0.02	0.010	—	0.005	—	—	0.025	—	—	< 0.020
WQ0089	1978-08-16	< 0.02	0.005	—	< 0.005	—	—	0.020	—	—	0.070
WQ0089	1978-09-12	< 0.02	< 0.005	—	0.005	—	—	0.005	—	—	< 0.020
WQ0089	1978-10-17	< 0.02	< 0.005	—	0.005	—	—	0.020	—	—	0.8[a]
WQ0088	1976-01-27	—	0.005	0.02	0.010	10.0	< 0.02	0.010	2.9	20	0.040
WQ0088	1976-02-16	—	0.005	< 0.02	< 0.010	8.00	< 0.02	< 0.010	2.3	< 10	< 0.005
WQ0088	1976-03-16	—	0.005	< 0.02	0.020	7.00	< 0.02	0.010	2.2	10	0.050
WQ0088	1976-06-29	—	0.009	0.08	< 0.010	9.00	0.02	< 0.010	2.8	20	0.060
WQ0088	1976-07-26	—	< 0.005	0.02	< 0.010	8.00	< 0.02	< 0.010	2.1	10	0.280
WQ0088	1976-08-17	—	< 0.005	< 0.02	< 0.010	10.0	< 0.02	0.010	2.8	45	0.080
WQ0088	1976-09-22	—	< 0.005	< 0.02	< 0.010	10.0	< 0.02	< 0.010	2.7	20	0.080
WQ0088	1976-10-13	—	0.010	< 0.02	< 0.010	8.00	< 0.02	< 0.010	2.9	18	< 0.05
WQ0088	1977-03-01	—	0.015	< 0.02	< 0.010	9.00	< 0.02	0.020	3.3	20	0.050
WQ0088	1977-05-31	—	0.005	< 0.02	0.010	9.00	< 0.02	0.025	3.3	20	0.080
WQ0088	1977-07-12	—	0.005	< 0.02	< 0.005	10.0	< 0.02	0.010	2.8	22	0.075
WQ0088	1977-08-17	—	< 0.005	< 0.02	< 0.005	8.00	< 0.02	< 0.005	2.8	20	0.060
WQ0088	1977-09-20	—	< 0.005	0.02	0.010	8.00	< 0.02	< 0.005	2.8	20	0.060
WQ0088	1977-10-17	—	0.005	0.04	0.010	10.0	0.02	0.010	2.9	20	0.150
WQ0088	1978-02-08	—	< 0.005	—	0.005	—	—	0.010	—	—	0.070
WQ0088	1978-03-08	< 0.02	0.005	—	< 0.005	—	—	< 0.005	—	—	0.050
WQ0088	1978-06-06	< 0.02	0.005	—	0.015	—	—	0.030	—	—	0.120
WQ0088	1978-07-11	< 0.02	0.010	—	< 0.005	—	—	0.010	—	—	0.070
WQ0088	1978-08-16	< 0.02	0.005	—	< 0.005	—	—	0.020	—	—	< 0.020
WQ0088	1978-09-12	< 0.02	< 0.005	—	0.005	—	—	0.005	—	—	0.040
WQ0088	1978-10-17	< 0.02	0.005	—	0.005	—	—	0.020	—	—	0.100
WQ0088	1979-01-10	—	0.005	—	0.005	—	—	0.020	—	—	0.050
WQ0088	1979-02-06	—	0.005	—	0.005	—	—	0.010	—	—	0.040
WQ0088	1979-03-07	—	0.005	—	0.005	—	—	0.005	—	—	0.060
WQ0088	1979-06-14	—	0.010	—	0.010	—	—	0.025	—	—	0.100
WQ0088	1979-07-10	—	0.020	—	0.005	—	—	0.010	—	—	0.100
WQ0088	1979-08-15	—	< 0.005	—	0.015	—	—	0.020	—	—	0.070
WQ0088	1979-10-18	—	0.005	—	0.015	—	—	0.025	—	—	0.090
WQ0088	1980-01-09	—	0.010	—	0.010	—	—	0.015	—	—	0.080
WQ0088	1980-02-13	—	0.015	—	0.010	—	—	0.005	—	—	0.060
WQ0088	1980-03-11	—	0.010	—	0.005	—	—	0.005	—	—	0.120
WQ0088	1980-06-11	—	0.005	—	0.010	—	—	0.010	—	—	0.090
WQ0088	1980-07-09	—	0.005	—	0.005	8.50	—	0.038	—	—	0.070
WQ0088	1980-08-12	—	0.005	—	0.005	8.00	—	0.013	—	—	0.060
WQ0088	1980-09-11	—	< 0.005	—	< 0.005	8.00	—	0.025	—	—	0.070
WQ0088	1981-01-21	—	0.010	—	0.010	5.00	—	0.030	—	—	0.180
WQ0088	1981-02-17	—	0.005	—	0.005	8.00	—	0.015	—	—	0.060
WQ0088	1981-03-17	—	0.010	—	0.010	7.00	—	0.010	—	—	0.060
WQ0088	1981-06-03	—	0.005	—	0.005	8.00	—	0.010	—	—	0.090
WQ0088	1981-07-29	—	0.048	—	< 0.005	8.00	—	0.014	—	—	0.070
WQ0088	1981-10-06	—	0.060	—	< 0.005	8.00	—	< 0.005	—	—	0.070
WQ0088	1982-01-12	—	0.067	—	< 0.005	8.00	—	< 0.005	—	—	0.050
WQ0088	1982-02-09	—	0.030	—	< 0.005	9.83	—	< 0.005	—	—	0.060
WQ0088	1982-03-10	—	0.048	—	< 0.005	8.54	—	< 0.005	—	—	0.050
WQ0088	1982-06-08	—	—	—	—	9.06	—	—	—	—	—
WQ0088	1982-07-08	—	0.020	—	< 0.005	7.72	—	< 0.005	—	—	0.090
WQ0088	1982-08-16	—	0.013	—	< 0.005	8.00	—	< 0.005	—	—	0.030
WQ0088	1983-07-05	—	< 0.005	—	< 0.005	6.83	—	< 0.005	—	—	0.030
WQ0088	1983-08-23	—	< 0.005	—	< 0.005	8.84	—	< 0.005	—	—	0.040
WQ0088	1983-09-21	—	< 0.005	—	< 0.005	9.86	—	< 0.005	—	—	0.070
WQ0088	1984-01-11	—	0.030	—	< 0.005	8.63	—	< 0.005	—	—	0.030
WQ0088	1984-02-07	—	0.005	—	< 0.005	8.55	—	< 0.005	—	—	0.040
WQ0088	1984-03-06	—	0.010	—	< 0.005	8.20	—	< 0.005	—	—	0.040

a. Outlier value of 0.8 mg/L for zinc at site WQ0089 on October 17, 1978 may be in error and is excluded from calculations.